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# MOTION PICTURE

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## ENGINEERS

Stereographic Animation
Television for Motion Picture Industry Use
Radial-Tooth, Variable-Pitch Sprocket
Carbon Arcs for Studios
Magnetic Sound on Film
Cine-Interval Recording Camera
Reader for Data Analysis
Public Address Committee Report
Society Emblem Committee Report
American Standards

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Part II, Index to Volume 57

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# Stereographic Animation—

## The Synthesis of Stereoscopic Depth From Flat Drawings and Art Work

By NORMAN McLAREN

With Appendix by CHESTER BEACHELL

**A description is presented of various methods of producing a stereoscopic pair of motion pictures by photographing subject matter which in itself is two-dimensional and by using only standard monocular animation and optical equipment.**

In 1950 the Festival of Britain asked the National Film Board of Canada to contribute two shorts for a program of stereoscopic and stereophonic films being shown at the Tele-kinema in London, with the specific request that the films be of an animated nature, to contrast with the "live" stereo films being made by the British themselves.

To our knowledge little had been done in three-dimensional animation. In 1939 the Loucks and Norling Studios pioneered with a very brief cartoon sequence in a film whose technique otherwise was a brilliant example of stereoscopic animation in the sense that solid objects were photographed using a stereo camera and stop motion; a description of this film was presented by J. A. Norling to this Society in 1939.*

Stop motion of a solid scene shot by a stereo camera is indeed one solution to the problem of the animated stereo film, and would recommend itself for all puppet and model work.

Our problem, however, was somewhat different, for we were concerned with the making of a stereoscopic film entirely from drawings, art work or other material which was flat in itself; in other words, we had to synthesize three-dimensional space from two-dimensional subject matter.

Since the subject matter to be photographed was flat, no special stereoscopic camera was needed, but simply the regular type of animation and optical

Presented on October 19, 1951, at the Society's Convention at Hollywood, by Norman McLaren, National Film Board of Canada, John Street, Ottawa, Canada.

*J. A. Norling, "Three-dimensional motion pictures," *Jour. SMPE*, vol. 33, pp. 612–634, Dec. 1939.

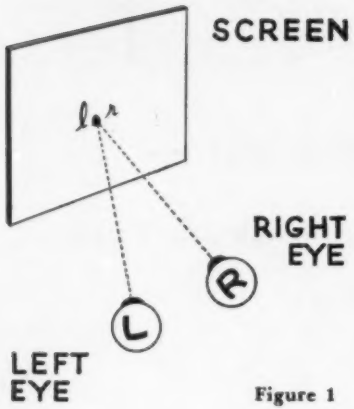


Figure 1

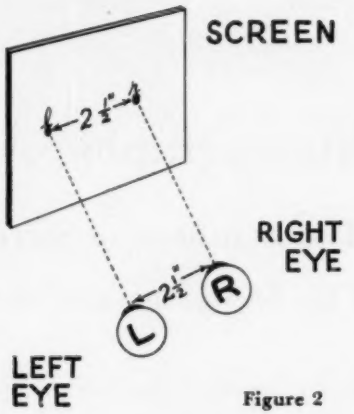


Figure 2

setup, the film for each eye being shot in succession.

Many possible technical approaches suggested themselves, the most obvious being that of adapting the standard cartoon technique by preparing two sets of drawings, a left- and right-eye version of each cell, with all the necessary parallaxes drawn into each cell. This technique, however, was discarded, due to limitations of time, staff and budget, in favor of several simpler methods which this paper will describe in detail.

Before doing so, it might be useful to review in simple language the principles behind the animator's approach to creating depth.

**The Control of Depth by the Animator**

In essence, this is done by controlling the amount of toe-in or toe-out of the spectator's eyeballs.

When a spectator looks at the screen in a normal flat cinema, the lines of sight from his left (L) and right (R) eyes are toed-in so as to meet each other at a point (lr) on the surface of the screen, as in Fig. 1.

Throughout the viewing of a normal flat film, the spectator's eyeball toe-in remains fixed. In viewing a stereoscopic film, however, this toe-in varies.

If our spectator, instead of looking *at* the screen, were to let his eyes drift and look away beyond the screen, staring at infinity, the lines of sight from his eyes (L and R) would become parallel, as in Fig. 2, and these lines would pass through the screen at two separate points (l and r).

Since the distance between the average spectator's left and right eye is 2½ in., and since his lines of sight are parallel, the distance between the two points on the screen (l and r) will be 2½ in. No matter at what distance from the screen the spectator is sitting, this will always be so.

Now, if our spectator were to look at an object located exactly halfway between himself and the screen, his lines of sight would cross each other at a point (lr) halfway between himself and the screen, as in Fig. 3, and the lines of sight, if projected beyond this point, would fall on the screen at two points, l and r.

Again, by simple geometry, we can see that the distance between l and r is 2½ in., and that no matter what distance the spectator is from the screen, this will always be so; it is important to note that l and r are now switched, so that l is to the east and r to the west.

For the stereoscopic animator, these are three basic diagrams on which to

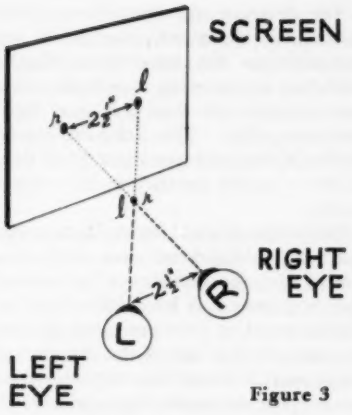


Figure 3

anchor all calculations of parallaxes. In designing a stereoscopic scene from flat drawings, the artist, if he wishes, let's say, a dot to appear on the surface of the screen, must have the left- and right-eye versions of the dot coincide precisely. For the dot to appear at infinity, there must be a 2½-in. separation between the left- and right-eye images on the final screen, the left-eye image being on the left side of the screen and the right-eye image on the right.

For the dot to appear midway between the spectator and the screen, there must again be a 2½-in. separation between the two images, but this time the left-eye image is on the right side of the screen, and the right-eye image on the left.

If the images are separated by progressively less than 2½ in., the dot will be located progressively nearer to the screen than halfway, or nearer to the screen than infinity.

Separation of more than 2½ in. for back-of-screen images has generally to be avoided as it places the object "beyond infinity," a condition which, due to the spectator's having to wall-eye, is almost as awkward to perceive as conceive. Separations of much more than 2½ in. to bring the image closer to the spectator than midway can be used, but sparingly, in order to avoid eye strain for a certain percentage of the spectators

The animation artist, therefore, is not troubled by the major limitations, such as depth of focus, lens separation, lens toe-in, etc., which afflict the regular cameraman in stereoscopy. The stereoscopic world created by him is so calculated that no part of it will exceed the tolerable limits of parallax when projected on the screen, that is, so long as he knows the maximum size of screen on which his film is to appear. Knowing this size of screen, the amounts of parallax on its surface can be mathematically translated into amounts of parallax on the surface of the 35-mm film, and that, in turn, can be converted into amounts of parallax on the surface of the cell, cards or other art work.

The screen for which these Canadian films were designed was 15 ft wide, this being the requirement for the Tele-kinema in London, England, where two interlocked 35-mm projectors were lined up with their optical axes converging at the surface of the screen.

The pioneering work in the mathematics of three-dimensional projection by John T. Rule,* and more specifically an as yet unpublished paper by R. J. Spottiswoode entitled "The Determination of Stereoscopic Parallaxes in Animation," were used as a basis for calculating all parallaxes.

There follows a detailed account of the various production techniques used in the two films entitled *Now Is the Time* and *Around Is Around.*

### Techniques Used in "Now Is the Time"

*Parallax by movable cutouts in the art work.* The opening scene of *Now Is the Time* is progressively built up of twelve planes of clouds, each flat in themselves, starting from the most distant and working forwards.

The most distant plane was located

* John T. Rule, "The geometry of steroscopic projection," *J. Opt. Soc. Am.*, vol. 31, p. 325, Apr. 1941.

at stereoscopic infinity. The nearest plane was located approximately halfway between the spectator and the screen.

The material prepared for shooting consisted of one black card 10 × 14 in. Clouds, varying in size from ¼ to 3 in. wide, were painted with white paint on small bits of black card. These were then stuck to the black card with double-sized tape in a series of horizontal rows varying in size from the smallest row in the center of the card to the largest at the bottom. The card was then placed under a standard animation camera and photographed on high contrast stock in such a way that the various rows of clouds were revealed in turn by a series of cross fades. This shooting was for the right-eye viewpoint; the card was then kept in the same position under the camera, but the lateral position of all the clouds on the card was changed. The cloud cutouts were moved in varying amounts either to the east or to the west to allow for the desired amount of parallax. Only one plane of clouds was left untouched, the one located on the surface of the screen. The parallactic shift was mathematically calculated for only the farthest and nearest planes, the rest being adjusted by eye — a relatively simple matter. The card with clouds was then shot again, following the same footage dope-sheet as before, to obtain the left-eye footage.

The sequence of appearing suns which follows the cloud sequence was done in the same way as the clouds.

*Parallax by lens-shift in the optical camera.* The little dancing man and the animation that grows out of it was done by a different method. With an ordinary writing pen and India ink, the action was drawn frame by frame directly on clear 35-mm machine leader (the usual animation stages of pencil sketches, inking, shooting and developing being short-circuited in the process of making the original negative).

The drawing was done from a mid-interocular viewpoint, that is, it was designed on the assumption that it would be representing a viewpoint midway between the final left- and right-eye viewpoints. The animated image itself was designed to remain at all times within a plane parallel to the cinema screen.

From this original hand-drawn negative, an optical print was made and loaded into the projector of a standard optical printer. A left- and a right-eye optical negative were produced in turn, the transverse action of the camera lens being used to create the required parallaxes. The amounts of parallax for the nearest and farthest planes were calculated mathematically. These amounts, split in half for each eye, were marked on the indicator controlling the transverse action of the lens on the optical camera, as movements to the left or right of zero position. The zero position itself represented the plane located on the cinema screen. A dope-sheet indicating the amounts of parallax required at key points in the animation was prepared. The dope-sheet for the right eye being the same as for the left except that, in shooting, the direction of transverse movement was reversed. The optical print was projected continuously at a speed of 160 frame/min, during which the artist, by glancing at the dope-sheet and watching the animation, turned the transverse control and created variable parallax in sympathy with the linear perspective of the flat drawing.

In cases where the parallax changed rapidly and in a varied fashion, the shooting was stopped periodically, or the camera run more slowly to secure greater control.

*Combining the above material for the release printing.* The left- and right-eye negatives from the optical camera bearing the animated images, and the left- and right-eye negatives from the animation camera

bearing the static backgrounds were then used as material for building up six parallel picture separation negatives (a yellow, cyan and magenta record for the left eye, and a yellow, cyan and magenta record for the right eye), for release color printing in English Technicolor.

*Stereophonic animated sound track.* Strictly speaking, the music of the film *Now Is the Time* should be classed as animation. This synthetic sound was produced by photographing patterns of black-and-white sound waveforms onto the sound track area of 35-mm film, using standard animation equipment and techniques.

The stereophonic system used in the Tele-kinema at the Festival of Britain employed four channels. To make the animated sound stereophonic, four identical prints were lined up parallel in a four-way, each representing one of the channels. Various notes were then blooped out of certain of the tracks, depending on which channel or channels the sound was desired to come from. This was possible because the animated sound was built out of small units each separated by small sections of unmodulated track.

**Techniques Used in the Film "Around Is Around"**

*Parallax by double punch-holes on art work.* The opening build-up of eight planes of stars was produced as follows:

The stereoscopic location of the eight planes was decided upon, and from this in turn were calculated the amounts of screen parallax, the amounts of parallax on the surface of 35-mm film, and the amounts of parallax for art work with a field 12 in. wide.

Eight standard animation cells (10 × 14 in.) were then punched with two sets of registration perforations; the distance between the two sets of punch-holes varied for each cell and depended on the amount of parallax required for the plane represented by each cell.

The plane representing the surface of the screen had only one set of punch-holes, there being an absence of parallax for that particular plane.

The art work (stars in this case, and representing no depth in themselves) was then painted on the eight cells. In order to prevent the final stereo scene from being asymmetrical, during the painting, the cells, when placed on top of each other, were registered for a mid-interocular viewpoint, that is, the mid-way points between the two sets of punch-holes were registered with each other.

In shooting, a standard animation camera and stand with registration pins and glass platten were used. The eight cells were not separated physically in space, but pressed close together under the glass platten. They were registered by the set of punch-holes for the right eye and shot once, then registered by the other set of punch-holes and shot a second time, for the left eye.

All static background material for the film *Around Is Around* was shot in this fashion.

*Parallax by frame-stagger on the negative.* The horizontal panning backgrounds of clouds and stars were cases in which the speed of travel of the various planes was so calculated that the dynamic parallaxes of a monocular panning shot gave rise automatically, when two identical prints were staggered by a certain number of frames, to the required binocular parallaxes for a stereo pair.

The monocular cloud and star panning shots were made by multiple exposures, the various planes, each with a different travel speed, being superimposed in the animation camera.

Assuming a one-frame stagger, the travel speeds for various planes were calculated. For example, for the infinity plane: The amount of parallax needed on the surface of the 35-mm film to locate a plane at infinity is known, therefore, the corresponding amount of parallax needed on art work of a given

field width can be calculated. This amount is the same as the amount of travel per frame required to locate this plane of the art work at infinity. Speeds progressively less than this will locate planes progressively closer than infinity, until an absence of any movement will locate the plane on the surface of the screen.

To locate subject matter *behind* the screen in a panning shot in which the subject matter is traveling eastward, frame 1 for the left eye should be placed opposite frame 2 for the right eye (L1 = R2). For westward traveling subject matter, R1 = L2.

If in the above shot with *eastward* traveling material the stagger is reversed, or the left- and right-eye films are switched (R1 = L2), then the planes are located stereoscopically between the surface of the screen (for the plane with no movement) and a point midway between the spectator and the screen (for the plane with maximum speed); similarly with westward traveling subject matter, when R2 = L1. To state this more briefly:

To locate planes in back of screen:

with eastward traveling subjects, L1 = R2;
with westward traveling subjects, R1 = L2.

To locate planes in front of screen:

with eastward traveling subjects, R1 = L2;
with westward traveling subjects, R2 = L1.

In the latter two cases, faster travel can be used for locating planes closer than halfway between the spectator and the screen; but in the former two cases, if faster travel is used the planes will be located beyond binocular infinity.

If a two-frame stagger is used and the same stereoscopic effect desired, the speed of travel of each plane has to be halved; if not, the total gamut of depth will be doubled.

A three-frame stagger will triple the depth gamut, unless the speeds of travel are divided by three, and so on.

In *Around Is Around* a seven-frame stagger was used for the white-on-magenta horizontal panning clouds, and a two-frame stagger in the last sequence of the film for the cyan stars on a blue background.

The frame-stagger technique was also used to create the stereo depth of all the linear animated images in *Around Is Around*.

These revolving images, Lissajous figures and other patterns were produced on an oscillograph, and a brief description of their means of production is given in an appendix to this paper.

A standard Bell & Howell camera was trained on an oscillograph, and the patterns photographed while in motion. The growth and change of the patterns were controlled by manually operating the control knobs on the oscillographic setup. The camera was run at 12 and also 8 frames/sec, rather than normal speed, to permit greater control of pattern modulation.

The movement of the patterns was kept predominantly horizontal, so that the monocular dynamic parallax would produce binocular parallax, when two identical prints were staggered as a stereo pair. The movement had to be slow enough to prevent the parallax between two adjacent frames from exceeding the tolerable limits of parallax for infinity. On the slower patterns a two-frame stagger was possible; on the quicker, a one-frame. Any vigorous vertical movement within the patterns was avoided, for this, due to the frame-stagger, would have created undesirable vertical parallax in stereo-viewing.

*Parallax by frame-stagger plus lens-shift.* Rotating patterns which travelled to and from the audience achieved their depth by combining frame-stagger and lens-shift techniques.

An optical print from the original

negative was shot twice on the optical camera, once for each eye, the parallax relating to the eventual to-and-fro movement of the pattern being introduced by camera lens-shift while shooting; the two resulting negatives were then staggered to produce the parallax relating to the rotational movement.

**Conclusion**

The above covers the various techniques used in the two films under review, and leaves untouched a number of others which were considered but not tried out.

Our particular choice of techniques was dictated by the setup at the National Film Board of Canada, and by our desire not to simulate reality (a thing which natural stereo photography can do most ably) but to create a new kind of reality more in keeping with the graphic method by which the films were produced. We were also interested in dispensing with some of the nonstereoscopic depth-assessing factors normally present in stereo films, such as interruption by opacity, light and shade, chromatic, hue, and tonal perspective, and to some extent diminishment (in the oscillographic patterns — which, however, have dynamic foreshortening) in order to discover to what extent and in what order the human mind relies upon these factors for depth information.

To sum up, our production experience would suggest that the major methods of introducing parallax into flat drawing and animation are probably:

1. stereo pairs of cards or cells, the parallax being drawn into the images,
2. double punching of single cards or cells,
3. movable cutouts,
4. movements of the horizontal panner under the animation camera,
5. horizontal panning or lens-shifting in the optical printer, and
6. frame-stagger on horizontal action shots.

Each method would seem to be effective for different purposes; obviously Method 1 has the greatest flexibility, and would recommend itself for cartoon work, particularly when combined with Method 2 for static backgrounds. On the other hand, for diagrammatic and cartographic animation some of the other methods may well be more suitable and economical, especially when the final visual is built out of several superimposed elements. At all events, it is quite safe to predict that combinations of all these methods will be useful for stereo animation, and that they will, in the future, become part of the technical ammunition with which the animated film will meet the challenge of stereoscopy.

**Appendix: The Generation of Oscillographic Patterns in "Around Is Around"**

There is no limit to the patterns obtainable on an oscillograph. This is easy to understand when we remember that a picture tube in a television receiver is a glorified oscillograph.

However, it was decided to keep the patterns relatively simple for two reasons:

(1) the difficulty of photographing an extremely complicated trace due to the low actinity of the fluorescent screen at high trace speeds, and

(2) the presence of vertical movement in the more complicated patterns.

The patterns themselves are mostly complete cycles — that is the sweep was sinusoidal — except for one or two patterns, notably the pillars. With a sinusoidal sweep the return trace is the same rate as the forward trace, and hence is visible, giving a closed loop.

There were never more than four component signals used to form any of the patterns in this film. The wave forms used were (a) sinusoidal, (b) square wave and (c) saw-tooth wave, including varying shapes and distortions

of the original waveforms. In some patterns varying degrees of phase shift were employed between vertical and horizontal deflection in order to produce such things as the revolving spring pattern.

The signal sources were: two audio-frequency signal generators with a range of 20 to 20,000 cycle/sec, one audio-frequency signal generator with a range of 7 to 70,000 cycle/sec and one square-wave generator with a range of 7 to 70,000 pulse/sec and 60-cycle line frequency.

A number of external and separate controls were set up in order that the size, movement, brightness and shape of the patterns could be changed and accurately controlled during any one shot. These controls were: (1) vertical micro gain, (2) horizontal micro gain, (3) mixing controls for the various waveforms so that they could be mixed on either or both sets of the deflection plates, (4) phase-shift controls set up so that they could be inserted in any signal source to either deflection system, and (5) a switch to rotate the pattern through 90° on the screen. This was necessary in order to keep the movement largely in the horizontal plane.

As the revolving movement in the patterns is a graphic presentation of the beat between two frequencies, it was necessary that all signal sources be as stable as possible. Instability caused varying rates of movement on the screen and if a pattern moved too fast, then the optical parallax, in final stereoscopic viewing, became too great. This was our biggest difficulty in that regulation had to be absolute in the power source, as any change in voltage in the oscillators or in the scope itself brought on unwanted movement. It was found that saturable core regulation transformers were a partial answer to the supply regulation problem; but, even with this, most of the shooting was done at night when there were no heavy intermittent loads on the a-c power.

Due to the low actinity of the phosphor used — the oscillograph tube was a 5LPI — it was necessary to shoot at varying frame rates depending on the complexity of the pattern. This was also an advantage as it permitted greater manual control of the figure during shooting. This brought on another difficulty, to slow the movement of the pattern so that the movement would be within reason when projected at 24 frame/sec. As an example: the base frequency is 60 cycle/sec. The beating frequency is the one-thousandth harmonic which is 60,000 cycle/sec. In order that the pattern will move, it is necessary to change one of the frequencies so that the beat frequency between them is 0.05 cycle/sec. This would mean absolute stabilization of the 60-cycle/sec signal and absolute stabilization of the second frequency at either 59,999.95 cycle/sec for clockwise rotation, or 60,000.05 for counterclockwise rotation. This meant that differences in frequency from one signal source to the harmonics of that frequency obtained from another signal source were as little as one-twentieth of a cycle per second. Crystal oscillators were impractical because a roomful of crystals would have been required.

The fireworks effect was achieved by charging the capacitor on the vertical positioning supply through a high resistance to a voltage greater than that required to center the beam and then bleeding it down to center position through another large resistance.

The most simple description of these patterns is that they are graphic presentations of the sums of the equations of various waveforms at any given instant in time.

# Examination of Some Aspects of High-Quality Television for Motion Picture Industry Use

By BLAIR FOULDS and E. A. HUNGERFORD, Jr.

**The day is coming when television will be a basic distribution medium for the motion picture industry. Equipment requirements for this purpose may well be different and more exacting than those currently accepted for television broadcasting. A review of the present state of the art, from a description of modern television equipment and consideration of some of the factors involved in adapting television for motion picture use, enables one to make an "educated guess" as to the potential needs of Hollywood in the light of what is now possible.**

In *Variety*, dated Wednesday, September 19, 1951, there appeared a very significant article under the headline, "Arenas, Theatres in TV Battle." The article announced the intention of the International Boxing Club to operate its own circuit of big-screen television displays located in the boxing arenas throughout the country. Although Mr. Ned Irish has since called this "unsound," there is still evidence that ultimately this will take place. What better bolstering of the box office of local arenas could be imagined? After the usual preliminaries of the less-known fighters, in Pittsburgh, for example, the lights dim and a feature bout of national interest then comes from New York by television. This is the type of program they need to sustain boxing's own farm system.

Presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by Blair Foulds and E. A. Hungerford, Jr., General Precision Laboratory, Pleasantville, N.Y.

The significance of this situation for the theater is quite clear. The motion picture industry was hoping to draw on another world, the sports world, to sustain box-office receipts in cities afflicted with the home television disease. This panacea may prove to be a will-o'-the-wisp. Fights and other big sporting events may well wind up on televised circuits in direct competition with the theater. In any case, they are too infrequent to be a major economic factor in theater television.

This may be a blessing in disguise. Let us see what would happen if fights, for instance, were to become commonplace fare. A typical fight audience is predominantly masculine, but the theater audience has always been a family audience. With fights an important part of the theater program, it is highly probable that the distaff side of the audience would be reduced. Although every Mr. Smith might want to see a fight, and even this is doubtful, certainly not every Mrs.

Smith would want to see it, by television or otherwise. Perhaps overemphasizing such sporting spectacles in theater television may place the theater in real danger of changing the character of its audience.

Nor can the theater turn to Broadway for much assistance. Two years ago, economic studies showed quite clearly that when Broadway gets ready, it can syndicate its own plays to the hinterland by large-screen television and justify little theaters in major cities, also in direct competition with the motion picture theaters. And so it is with every phase of the entertainment industry. Television can help if used wisely, but it must be remembered that television is first and last a distribution medium with greater efficiency and speed than any known heretofore.

This fact bears repeating — television is fundamentally a new medium of distribution. It finds its application in many fields. But what of the motion picture–television relationship? Perhaps the action of the International Boxing Club makes that clearer.

The motion picture industry must depend upon its own great resources to use television wisely for its own interests in perfectly natural applications. Thus far the theater side of the business has shown the most foresight and has truly been aggressive in trying to understand and use television. Theaters have installed theater television with very little idea of just what programs they would be able to show on their screens. Sometimes they use it as little as two or three times a month. Yet they are gradually building up a network which will wield tremendous force and are creating the market for enterprising showmen to supply with suitable entertainment.

Curiously this is just the reverse of the television broadcast industry. There the program producers and the broadcasters have to hit the air first, hoping that their audience will buy receivers to look in on them. They build their distribution system by broadcasting first, providing the bait which tempts the public to buy. They have been phenomenally successful. Hollywood producers, on the other hand, sit still while their audience, the theaters, buy television sets to receive programs that do not exist. The courage of the theater man is certainly to be admired. Less can be said of the major studios in whose hands lie the greatest accumulation of creative talent in this country. Utilization of television by the motion picture industry must be effected by combined action of Hollywood and the theater.

How, then, can this be accomplished? It is late, but not too late, for producers to take an active part in television production. Imagine Hollywood putting on a revue with its many stars and feeding it live by television to a hundred theaters in the Los Angeles area. Very few people would stay home to watch broadcast television if such a bill of fare were available at their local movie houses. Couple this with a magnificent feature picture in color. Here is an entertainment combination hard to beat. Think of the Radio City Music Hall stage show fed simultaneously to a hundred eastern theaters to bolster the neighborhood box office. Television would be distributing something to the theaters that they haven't had since the days of vaudeville. And those were good days.

Our purpose as engineers is to be very certain that when Hollywood wishes to enter television production, the proper equipment will be ready.

It is clear that the big theater screen needs higher-quality television than is presently broadcast to the home. Yes, it should also be in color, but let us walk before we run. Even black-and-white television has not yet achieved the quality necessary for the motion picture industry. But today appropriate equipment is on the drafting boards and it can be manufactured.

Otto H. Schade has indicated in his several talks to the Society the specifica-

tions for high-quality television.* Messrs. Garman and Lee† have also outlined a system differing in details, but suitable for the purpose. Referring to Garman and Lee, 675 lines were recommended as the scanning-line pattern. The frame frequency was set at 24 to meet the custom of the motion picture industry where the prevailing situation of relatively low screen-projection brightness permits it. Some day the frame rate may go to 30 frame/sec and we shall see how that may happen.

When Hollywood begins to use high-quality television equipment to produce programs augmenting the feature-film programs of the theaters, there will be times when the economics of production will dictate that the television offering be recorded on film and distributed as such to theaters not yet equipped with television projection systems. So long as the theater has present-day film projectors installed, the 24-frame standard is mandatory. However, the television industry knows full well the undesirability of televising at 30 frames and recording at 24. Enough of the picture material is necessarily thrown away so that results are very unsatisfactory when horizontal panning is taking place. To eliminate this effect, 24-frame television may be a temporary necessity for the motion picture industry, assuming that technical difficulties of handling a 24-frame standard do not prove uneconomical. Thirty-frame television is really only desirable in the future when all projection equipment in theaters may have been replaced by electronic television projectors capable of black-and-white or color. Then, theater television can swing completely to 30 frames, films can be made at the new rate and video recordings can be made at the new rate.

Once standards are fixed, the next important step is the design of pickup apparatus, particularly the camera chains.

At present no television pickup equipment of suitable high quality is available commercially. It depends upon image tubes which are still experimental, and reproducing systems which are also in the development stage, but a start has been made. Laboratory experimentation with the 675-line 24-frame standard has been encouraging. Flying spot scanners have been constructed and operated at these standards. Design of a camera to operate both on 675/24 and 525/30 is under way and shows great promise. Such a camera would permit Hollywood producers the greatest flexibility. For example, video recording or closed-loop operations can be accomplished at 675/24, while standard pickups can be made to feed present theater equipments at 525/30.

While awaiting the ultimate, it will be useful to examine the newest television camera chain now being used by the television broadcasters. Many of the operational features were designed with the use by Hollywood producers very much in mind. Figures 1 through 7 show this camera chain.

Figure 1 shows the most modern camera chain available today. The design contemplates both studio and field uses. It consists of three basic pieces of equipment, the camera head, the camera control unit and the camera control unit power supply. The fourth unit shown is a remote-control unit permitting the control of focus and lens change from the camera control unit location or other remote position, as desired. The camera

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*Otto H. Schade, "Image gradation, graininess and sharpness in television and motion picture systems—Part I, Image structure and transfer characteristics," *Jour. SMPTE*, vol. 56, pp. 137–177, Feb. 1951; "New system of measuring and specifying image definition," SMPTE Convention at New York, delivered on May 3, 1951; and "Requirements for a theater television system giving detail contrast equivalent to 35-mm motion pictures," SMPTE Convention at Hollywood, delivered on October 15, 1951.

†R. L. Garman and R. W. Lee, "A comprehensive proposal for a closed-loop theater television system," *Jour. SMPTE*, vol. 56, pp. 473–486, May 1951.

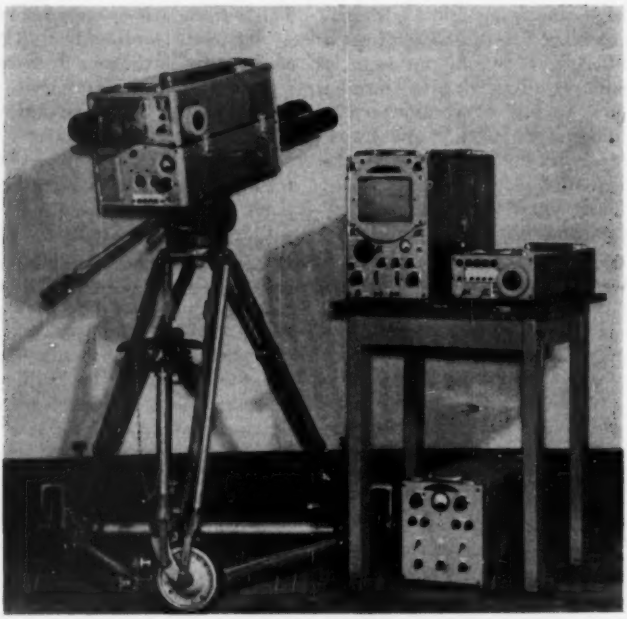


**Fig. 1. Modern television broadcast chain for field and studio use.**

is compact to permit maneuvering of many cameras simultaneously on the same studio set.

Since television is relatively complex and requires a certain amount of routine maintenance, this chain has been designed for maximum accessibility. Figure 2 shows the unit opened up, in which position it can still be operated normally while checks are being made.

Figure 3 is another view of this camera showing some of the controls. The operator's hand is on the focus knob which in this camera is the drive control of a servo system. In addition to providing easy remoting of the control, the circuitry provides the opportunity for ratio adjustment of the servo as a function of the focal length of the lens being used. Resistors built into individual lens mounts calibrate the servo so that 310° rotation of the focus control moves the image orthicon carriage not just so many inches, but a distance equivalent to the range from infinity to close up, matched to the focal length of the lens in use. Similarly, cams on the lens mount calibrate an iris reading system so that one meter reads the correct *f*-number setting of any action lens. Immediately below and to the left of this meter are push buttons, each of which is associated with a particular position on the turret. The turret mounts four lenses which can be of any focal length from two inches to twenty-four inches. Depressing the button associated with any particular lens immediately causes motor rotation of the turret to bring that lens into action by the shortest route.

Figure 4 shows the camera control unit where picture quality is adjusted. One significant advance is the two-way switch just beneath the lower right corner of the 8½-in. picture tube. This switch controls the iris on the camera lens. Imme-

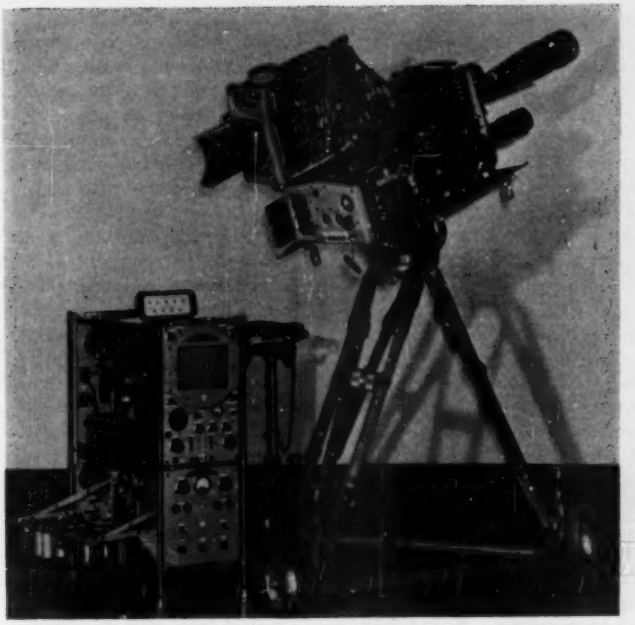


Fig. 2. Camera chain showing maintenance accessibility. Chain can be operated in this condition.

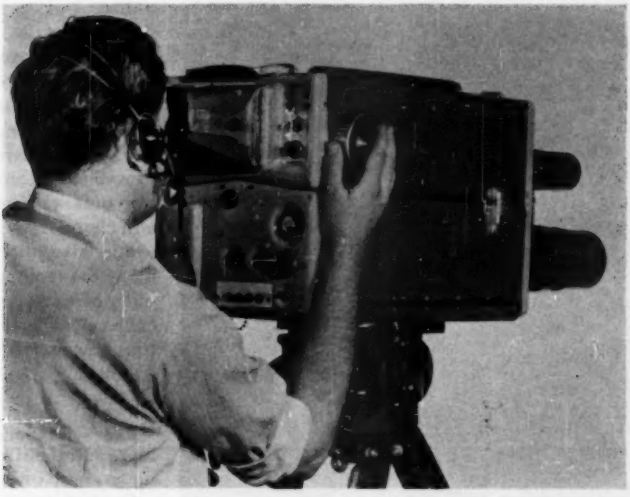


Fig. 3. Television cameral head, showing major controls.

diately adjacent is a meter which repeats the information on the camera meter, namely, the *f*-number setting. Just as with a film camera, the iris is most important in determining picture quality. If the image-orthicon tube is adjusted for proper operation, changing the iris is practically the only adjustment required over a fairly wide range of light. Now, for the first time, this control is available at the proper position so that the man responsible for picture quality can adjust the iris as he wishes.

In Fig. 5 is shown a synchronizing generator which is the nerve center of any television installation. This is a portable equipment and is significant principally for its compactness and stability. Binary counting is used, and all pulse widths are determined with reference to a delay line.

The switching unit is shown in Fig. 6. With a compact panel which can be swung into the unit for transport, this equipment provides for fades, lap dissolves and superimpositions, together with straight switching. Switch buttons are self-illuminating. The switching panel can be removed and extended as much as 5 ft for installation in proper console desks. As a companion piece, Fig. 7 shows the master monitor which views the output of the switcher, or previews dissolves or other effects. This team can handle as many as five cameras and two remote incoming circuits to provide the producer with adequate choice of shots.

The figures show the newest in television camera equipment, designed for the television broadcaster. The question is how closely does this equipment come to meeting Hollywood's requirements for motion picture applications? Whatever the technical standards pertaining to lines and frames, the physical form of the cameras can be much as you have seen or they can be packaged differently according to the dictates of the motion picture cameramen.

Several important design considerations should be discussed. Would Hollywood prefer optical viewfinders with their ability to see well beyond the photographed field, this in preference to electronic viewfinders which see essentially what the audience sees? This means duplicate lenses, of course, but perhaps it should be so. Does Hollywood want the cameramen to be in constant control of focus and lens change, or would it be better to have an assistant use a remote-control unit to hold focus and change lenses? This would give the cameraman the sole responsibility of maneuvering the camera to achieve the proper composition and balance.

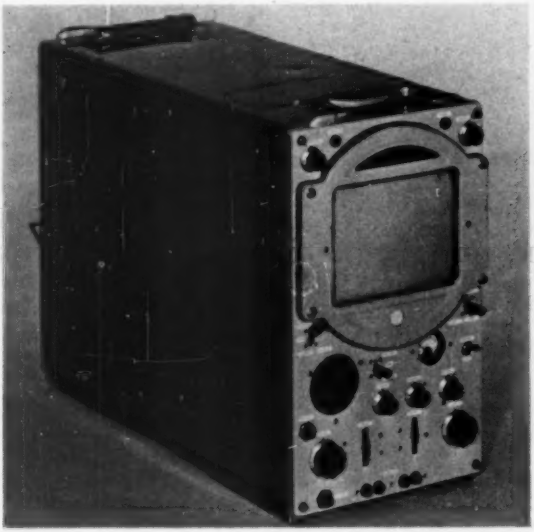


**Fig. 4. Camera control unit. Note iris reading meter, and iris control switch slightly up and to the right.**

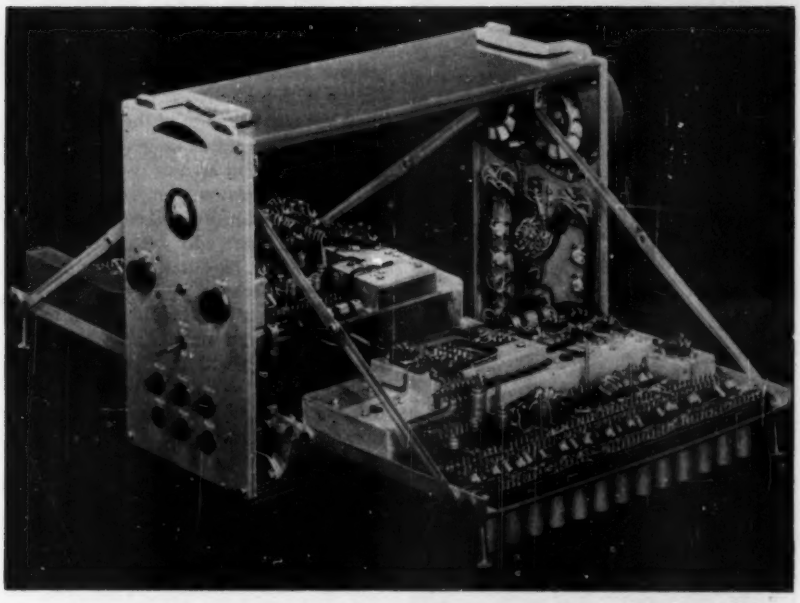


**Fig. 5. Pulse generator, showing ease of accessibility. Generator can operate in this position. Power supply is built in. All chassis are standard relay rack size for studio mounting.**

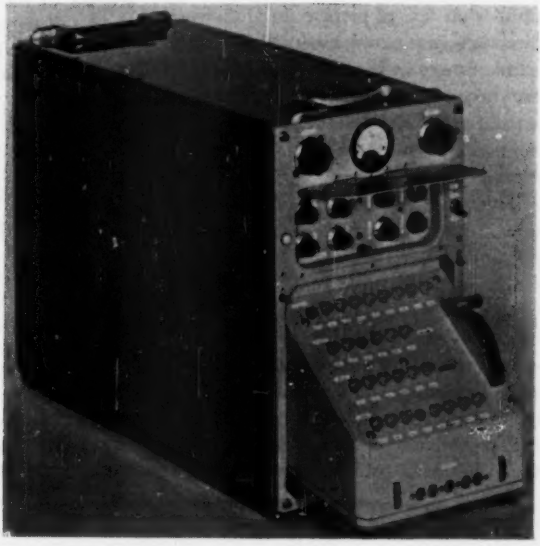


**Fig. 6. Switching and mixing unit, showing switching panel ready for action. Panel folds into unit for transport.**

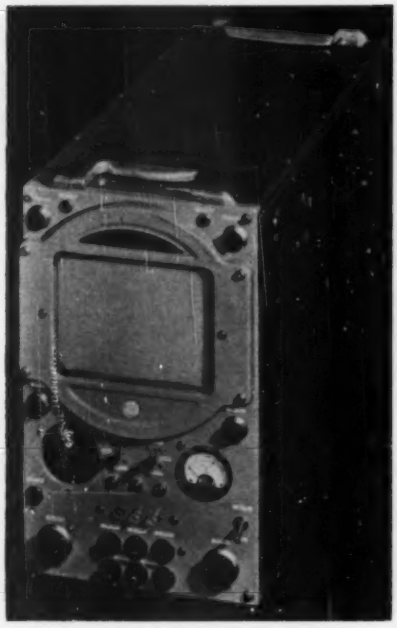


**Fig. 7. Master monitor.**

Or, to consider the camera control unit, what size of picture do Hollywood directors want to work with? What dynamic ranges in the system will they feel are necessary to achieve the required artistic effects? What optical effects are needed to meet the minimum requirements?

There are many more of these questions. But they are details. The important matter is the fact that the television manufacturer can now build equipment which will meet the requirements of the motion picture industry not only in regard to picture quality, but also as to flexibility and operational features for making the equipment most useful in the production of high-definition television for syndication to the theaters.

In addition to camera equipment for the live pickup aspect of television, machinery is now available for production to project motion pictures into a television system with a quality several times better than the current state of the art permits. Similarly, equipment for recording high-quality television signals is equally feasible. It remains only for the industry to tell the television manufacturers what is required. That will best be accomplished if the big motion picture producers take television into their own studios as the ally it can be, learn to use it, improve it and make it profitable. In so doing, they will probably find that some of the economies of television production may well be adapted to the motion picture industry, with resulting lower costs of production and greater output of standard product.

Within the motion picture industry are many men who are doing their utmost to understand television and its proper relation to their industry. They see the day when hundreds of theaters will play time and date alike, spreading the theater-load factor efficiently. Film and live production would be fed from central studios to the theaters. Television will be the distribution medium to the theaters — fast, efficient and sure. Already the theaters are beginning to build this distribution system on their own. How soon will the producer find ways and means to pump the finest of entertainment into this distribution system to the profit of all concerned?

Television should be used more and more by the motion picture industry. Its successful application depends, however, on the skill and talent of the producers and engineers within the motion picture industry. The next few years will undoubtedly see the entry of the production organization of Hollywood into television to properly cooperate with the distribution system being set up by the theater operators.

# The Radial-Tooth, Variable-Pitch Sprocket

By J. G. STREIFFERT

**A unique sprocket tooth whose driving face is a plane lying on a radius of the sprocket is used to improve longitudinal registration of the film over that obtained with conventionally shaped, curved-profile teeth. By supporting the film or films by means of an appropriately decentered drum while the films are in engagement with this sprocket, shrinkage accommodation is effected by virtue of the varying effective pitch of the sprocket. The variable-pitch effect also makes it possible to strip the film off the sprocket.**

**Calculated and measured flutter in sound prints and measured steadiness in picture prints made on a sprocket of this type in a 16-mm continuous contact printer are found to be substantially independent of film shrinkage and to be markedly better than in prints made on conventional printers.**

IT IS WELL KNOWN that ordinary sprockets can impart uniform continuous motion to film only if the film pitch happens to be identical with the sprocket pitch and the tooth profile is one which clears the path of the perforation as the film engages and disengages the sprocket. If the film pitch does not match the sprocket pitch exactly, only one tooth will be driving at any one instant, and, at the time of transfer of load from one tooth to the next, the film motion will not be uniform.

Various expedients have been employed to reduce this type of non-uniformity. In some cases, brute force is used to stretch the film so that it matches the sprocket or matches another film on which it is to be printed. This usually requires the application of inordinately high tensions and/or pressure on the film so that excessive wear of the film perforations and driving members is likely to occur.

In other cases, various forms of what may be called "shrinkage-accommodating sprockets" have been proposed. Among the more promising of these sprockets have been those of Elmer,[1] Mechau,[2] and Chandler.[3]

The Elmer disclosure described a sprocket whose base diameter was determined by the pitch of the longest film likely to be encountered, whereas the tooth profile was a curve intended to allow film of maximum shrinkage to

Communication No. 1449 from the Kodak Research Laboratories, a paper presented on October 17, 1951, at the Society's Convention at Hollywood, Calif., by J. G. Streiffert, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

slip back uniformly with respect to the base of the sprocket as it stripped off the teeth. By this means, films of minimum and of maximum shrinkage would be driven without flutter. For intermediate values of shrinkage, the film would be driven for part of each pitch length of travel at the speed of unshrunk film, and for the remainder of the pitch length at the speed of film of maximum shrinkage. If the sprocket were designed for a shrinkage range of 1%, the peak variation in velocity would be 1.0% for all intermediate values of shrinkage. The rms deviation in velocity, commonly referred to as "flutter," would depend on shrinkage, because this determines the relative time the film is driven at each of the two speeds. For a shrinkage of 0.5%, the times would be equal, and the rms deviation would equal the peak deviation of 0.5%.

The Mechau proposal is shown in Fig. 1. The film is driven by a wafer-like sprocket and is supported by rotatable disks on either side of the sprocket. The disks are slightly larger in diameter than the base diameter of the sprocket and are eccentrically mounted relative to the sprocket. This provides a continuously increasing effective sprocket radius as the film passes through its engagement with the sprocket. The presumption is that the effective sprocket pitch depends on the effective radius. Film of any shrinkage is automatically driven in that region where the effective sprocket pitch most nearly matches the film pitch.

Since no mention was made of the manner of determining the optimum tooth profile, the Mechau specification was incomplete until a geometrical analysis was published by Chandler. His analysis follows these lines: Referring to Fig. 1, assume that the film is fed onto the sprocket at the point where the supporting disks are tangent to the base of the sprocket. The perforation will then describe an epicycloid curve relative to the sprocket base as it moves along the surface of the supporting member and away from the center of the sprocket. This epicycloid curve would be the correct tooth profile to drive unshrunk film. The sprocket and film would be in perfect mesh, i.e., each tooth would bear against each perforation. However, if the pitch of the film were either slightly shorter or slightly longer than that of the sprocket, then either the last tooth or the first tooth engaged with the film would be the only one which did any driving, and the film motion would be nonuniform.

To achieve the variable-pitch sprocket, it is necessary to modify the epicycloid curve, as shown in Fig. 2. When this is done, it can be seen that the effective pitch of the sprocket, i.e., the distance between teeth along the film line, will continually *decrease* as the film passes from the tangent point to the point of disengagement along the supporting drum or "stripper." The result is that any film whose shrinkage is within the range for which the sprocket is designed is automatically driven in that region where the effective sprocket pitch matches the film pitch.

Several of these variable-pitch sprockets have been tried, particularly in 16-mm contact and optical printers. While all of these sprockets handled the shrinkage range for which they were designed, picture steadiness and sound flutter were not as good as was believed possible, on the basis of the known precision of the film and of the mechanical parts involved.

It can readily be seen that accurate longitudinal registration of a film by means of a sprocket tooth which presents an inclined face to the edge of the perforation, depends on accurate control of the distance of the driven edge of the perforation from the center of the sprocket. For example, if the driven edge of the perforation were drawn down into the slot between the two supporting disks on either side of the sprocket because of friction of the film on the

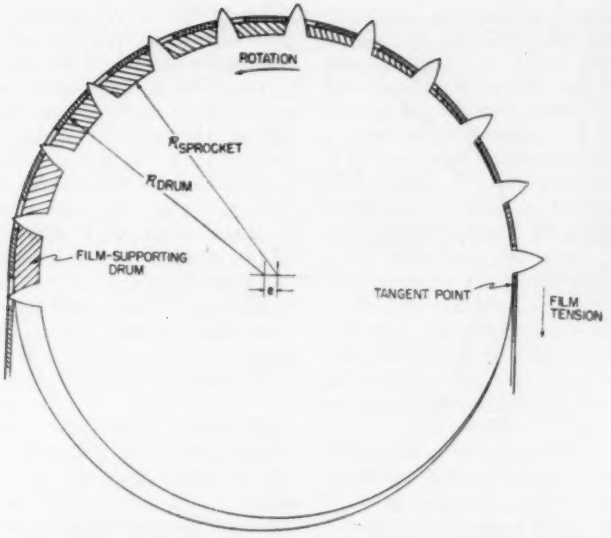



**Fig. 1. Variable-pitch, shrinkage-accommodating sprocket assembly. Film of maximum shrinkage would be driven at extreme left; that of minimum shrinkage, at extreme right.**

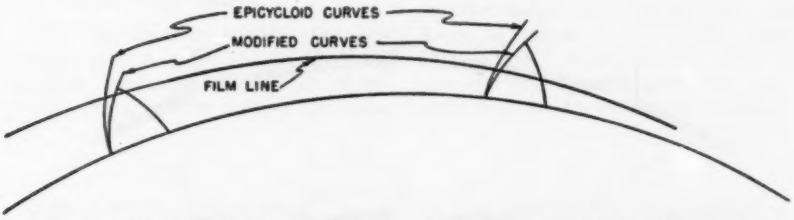



**Fig. 2. Modification of epicycloid curve. Distance along film line between epicycloid curves is constant; distance between modified curves decreases as film moves outward on teeth.**

teeth, then the film would not be correctly registered but would be advanced beyond its correct position. In order to avoid any such possibility, Sandvik and Chandler designed a printer in which the films were supported between the teeth as well as on either side. This was accomplished, as shown in Fig. 3, by recessing the sprocket inside the film-supporting drum and allowing the sprocket teeth to protrude through slots cut in the overhanging periphery of the drum. The drum was an integral member of pitch lengths greater in circumference than the sprocket and was engaged and driven by the sprocket in a gearlike manner. By this means, the film was supported directly under the point where the perforation bore on the tooth face and was pushed uniformly up along the profile as the assembly rotated.

Examination, by means of a microscope and stroboscopic illumination, of the action of the driven perforation

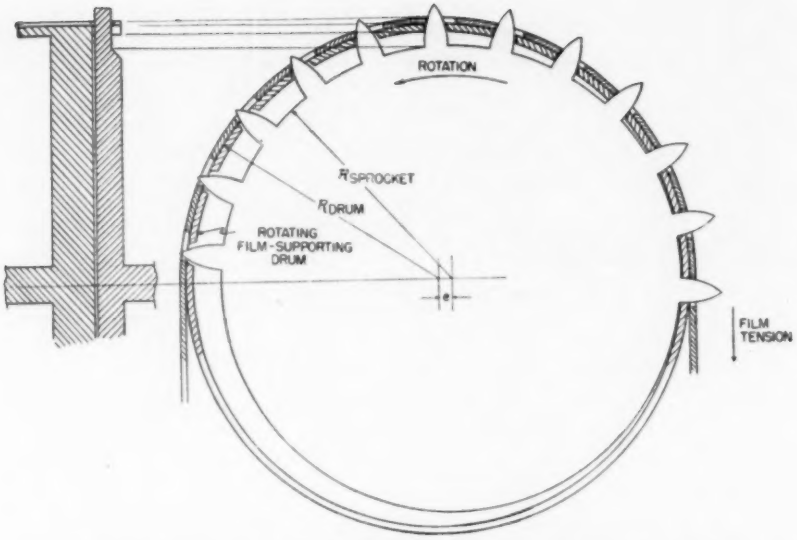



**Fig. 3. Rotating stripper, variable-pitch sprocket. Stripper is driven by gear action of sprocket teeth in slots in edge of drum.**

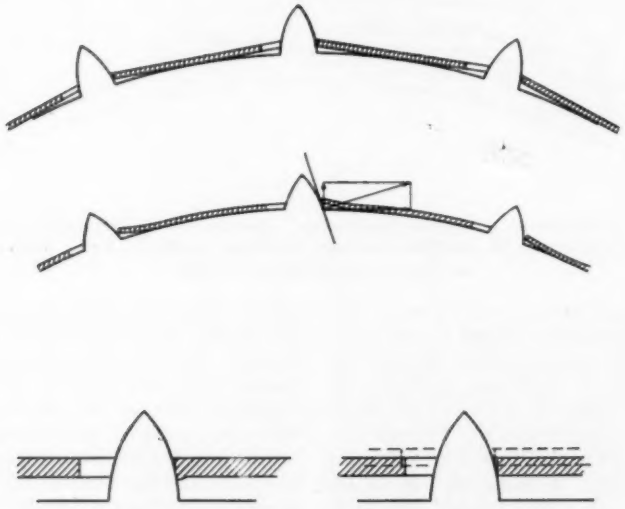


**Fig. 4. Causes of poor longitudinal registration: inaccurate radial positioning of film on the teeth, and physical distortion and bending of film.**

under the pressure of the driving tooth revealed that the film was not staying down against the drum, but was sliding up on the inclined face of the tooth by an amount varying from 0.001 in. to 0.003 in. Some of the causes for this are illustrated in Fig. 4. They include greater compliance and sharper bending of the film in the region of the perforation; distortion of the film because of the component of force normal to the film created by the driving force of the inclined tooth face; plastic deformation of the film under pressure; and non-uniformity of coefficient of friction from tooth to tooth and from perforation to perforation.

An attempt was made to reduce these errors by providing an external hold-down shoe of the same radius as the external surface of the film. While this resulted in substantial improvement, picture steadiness still did not meet expectations.

### The Radial-Tooth Concept

With the above-outlined studies as a background, it was realized that for accurate longitudinal registration of the film the ideal driving face for the tooth would be one which lay on a plane normal to the film (parallel to the sprocket axis), as shown in Fig. 5A. Essentially this would mean that the driving face of each tooth would lie on a radius of the sprocket. A driving face of this type would have several important advantages. It would produce no radial component of force on the film, thereby eliminating outward distortion of the perforation from this cause. It would bear squarely against the full thickness of the film instead of against the sharp, somewhat irregular corner of the film. The position of the film on the face of the tooth would have very little effect on longitudinal registration of the film. Such a tooth would in many ways be substantially the equivalent of a registration pin in an intermittent mechanism.

Under normal circumstances, the difficulty with using a tooth with a radial driving face is that it is impossible to get the film off the teeth, because the involute curve described by the driven edge of the perforation as it leaves the sprocket tangentially cuts into the radial tooth, as shown by the dashed curve in Fig. 5B. This difficulty can be circumvented by combining the radial tooth with the variable-pitch concept.

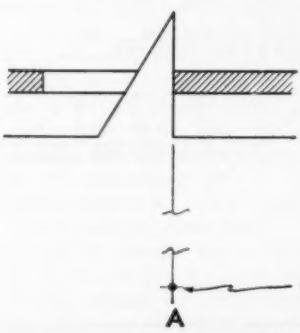



**Fig. 5A. Ideal tooth with driving face normal to film plane. Registration essentially independent of position of perforation on tooth face; greatly reduces errors from film distortion and bending.**

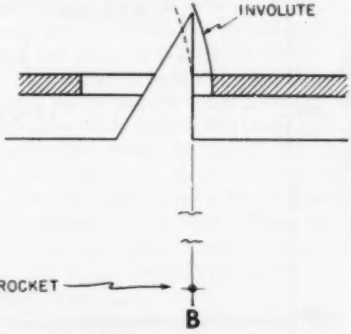



**Fig. 5B. Interference of film with radial tooth at the stripping point. Provision must be made for advancing perforation relative to tooth so that film can be disengaged from sprocket.**

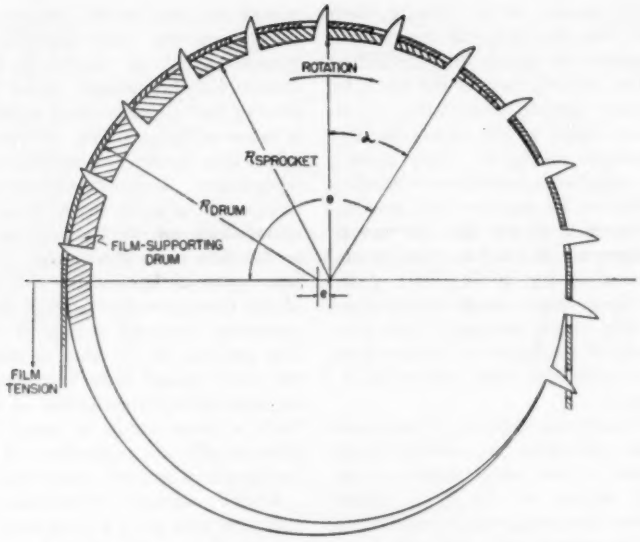



Fig. 6. The radial-tooth, variable-pitch sprocket.

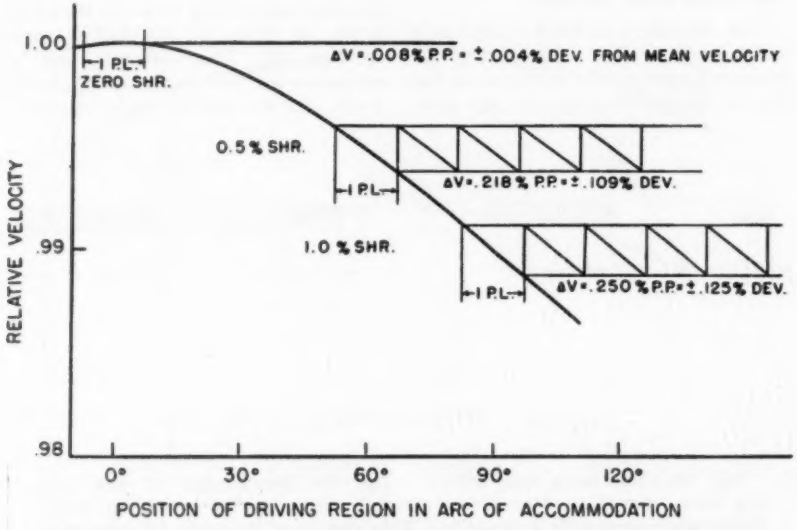



Fig. 7. Saw-toothed variation in film velocity caused by decreasing effective tooth velocity throughout arc of accommodation. P.L. = pitch length; P.P. = peak-to-peak.

In any variable-pitch sprocket, the change in effective sprocket pitch is the result of a changing effective tooth velocity along the film line. In the case of the radial-tooth variable-pitch sprocket, as shown in Fig. 6, the effective tooth velocity is a maximum when the effective sprocket radius is a maximum, i.e., when the film is at the tip of the teeth, and is a minimum when the effective radius is a minimum, i.e., when the film is at the base of the teeth. At some position between the points of maximum and minimum effective radius, the effective tooth velocity will be exactly equal to the lineal velocity at which film of a given shrinkage must be driven. To the left of this position, the effective tooth velocity will be greater than that of the film; and to the right, it will be less than that of the film. Thus, as a tooth travels through the arc of engagement, it is at first traveling faster than the perforation. Although its effective velocity is decreasing, it overtakes the perforation and drives for one pitch length, whereupon the next tooth takes over the driving function. The first tooth continues to decrease in effective velocity and falls behind the driven edge of the perforation so that there is again a clearance between the driving face of the tooth and the perforation.

This fact — that the tooth falls behind the perforation as it rotates beyond the driving region — provides the answer to the problem of getting film off a sprocket with radial teeth. The only requirement is that the shortest film which is to be accommodated, i.e., that film which requires the lowest lineal velocity, be kept in engagement with the tooth far enough beyond the region where it was driven to permit the tooth to fall far enough behind the perforation so that the film can be disengaged without interference, as shown by the solid curve in Fig. 5B. In practice, this means that the assembly must be designed so that the shortest film which is to be accommodated is driven at approximately the midpoint of the arc of engagement. The remainder of the travel provides for the clearance so that the film can be disengaged.

In Fig. 7 the effective tooth velocity is plotted as a function of sprocket rotation. Being a cosine function, the velocity decreases most rapidly when $\theta$ equals 90°. The change in velocity, $\Delta V$, which occurs during one pitch length of travel, repeats as each new tooth takes over the driving function and results in the saw-tooth film-velocity curves shown in the figure. One of the problems in design is to make this change in velocity as small as possible. This is done by including as many sprocket teeth as possible in the accommodation arc.

**Design Procedure**

In general, two factors, namely, the shrinkage range to be accommodated and the height of the perforation, define the limits within which practical designs of radial-tooth, variable-pitch sprockets are found. The effect of each of these factors will be apparent in the design procedure outlined below.

*1. Radius of Sprocket.* Since the tooth velocity changes slightly during the driving interval, it is desirable that the sprocket be large so that there will be a large number of teeth in the accommodation arc and the change in velocity per pitch length will be small. On the other hand, as the sprocket size increases, the required tooth height increases and the permissible tooth thickness decreases, so that the ratio of tooth thickness to height becomes impractically small if the sprocket is too large. Diameters of 2 to 3 in. for 16-mm sprockets and 3 to 6 in. for 35-mm sprockets appear to be most practical.

The radius of a sprocket that will fit unshrunk film is given by:

$$R_0 = \frac{N \cdot P}{2\pi} - \frac{t}{2},$$

where $N$ = the number of teeth, $P$ =

the pitch of unshrunk film, and $t$ = the thickness of film.

For a 25-tooth, 16-mm sprocket, this becomes

$$R_0 = \frac{25 \cdot 0.300}{2\pi} - \frac{0.0006}{2} = 1.1906 \text{ in.}$$

Since the percentage change in effective radius must be about twice that required to accommodate a given shrinkage range, the base radius of the sprocket must not be greater than:

$$R_s = R_0\left(1 - \frac{2s}{100}\right) = \left(\frac{NP}{2} - \frac{t}{2}\right)\left(1 - \frac{2s}{100}\right),$$

where $s$ is the maximum shrinkage to be accommodated in per cent. For a 25-tooth, 16-mm sprocket to accommodate a maximum shrinkage of 1%, $R_s$ = 1.1666 in.

*2. Shrinkage Accommodation.* The shrinkage range to be accommodated depends on the use to be made of the sprocket. In general, a sprocket to be used in a recorder does not need to accommodate as wide a shrinkage range as one used in a printer. In any case, the sprocket should be designed to accommodate a shrinkage range no greater than is absolutely necessary.

*3. Arc of Engagement.* If the film-supporting member is circular, as in Fig. 6, the arc of engagement is limited to a maximum value of 180°. Whether or not all of this can or need be used will be determined by other factors.

*4. Arc for Accommodation of Shrinkage.* Ideally, as much as possible of the arc of engagement should be devoted to accommodation of shrinkage while still leaving enough travel beyond the point where film of maximum shrinkage is driven, to permit that film to be disengaged. Since a mathematical determination of the optimal apportionment of these angles is complicated, it is easier to make the apportionment by trial. Actually, it has been found that very satisfactory designs can be realized if part or all of that portion of the arc of engagement to the left of the center of Fig. 6 is used for shrinkage accommodation, and as much as is necessary of the arc to the right of center is used for disengagement.

*5. Radius of Drum, Decentering.* The radius and the position of the film-supporting drum must be chosen so that the drum produces the required change in effective sprocket radius. If the first 90° of the arc of engagement is devoted to shrinkage accommodation, then the drum should have a radius equal to:

$$R_D = R_0\left(1 - \frac{s}{100}\right),$$

and the decentering would be:

$$e = R_0 \cdot \left(\frac{s}{100}\right).$$

For the 25-tooth, 16-mm sprocket,

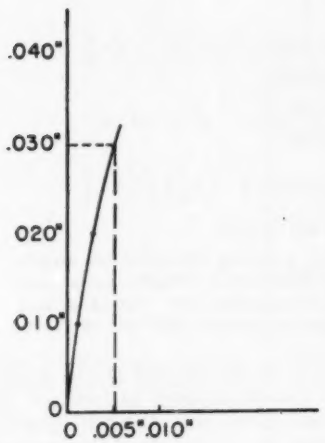
$R_D$ = 1.1786 in., and $e$ = 0.012 in.

*6. Arc for Disengagement.* The arc through which film of maximum shrinkage is required to travel beyond the midpoint of Fig. 6, before it can be disengaged tangentially, is determined by the involute curve and the height of the teeth.

*7. Involute Curve.* In Table I are given coordinates of points which, when multiplied by the sprocket radius, give

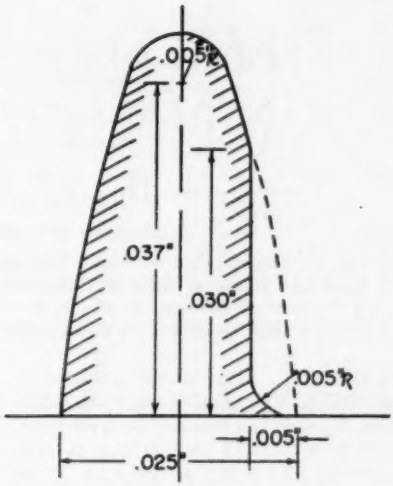
**Table I. Coordinates of Points on Involute Curve for Sprocket of Unit Radius**

| $\theta$ | x, in. | y, in. |
|---|---|---|
| 2° | 0.00002 | 0.00061 |
| 4° | 0.00013 | 0.00243 |
| 6° | 0.00040 | 0.00546 |
| 8° | 0.00093 | 0.00970 |
| 10° | 0.00182 | 0.01511 |
| 12° | 0.00305 | 0.02169 |
| 14° | 0.00484 | 0.02941 |




A

Fig. 8A. Involute curve for 25-tooth, 16-mm sprocket.




B

Fig. 8B. Tooth profile for 25-tooth, 16-mm, radial-tooth, variable-pitch sprocket.

the involute curve for that sprocket. The curve is plotted in Fig. 8A for the 25-tooth 16-mm sprocket.

*8. Height of Teeth, h.* Assuming that the arc of engagement equals 180°, in order for the tooth to protrude through one thickness of film at the extreme left in Fig. 6 where the effective radius is a maximum, the tooth height should be at least $2e + t$, where $t$ is the film thickness. By marking this height on the involute curve, as in Fig. 8A, and by drawing a vertical line to the base, the distance which the perforation must be ahead of the radial tooth face at the tangent point is determined. For the 25-tooth sprocket, $h = 2e + t = 0.030$ in., and it is seen that a clearance, $c$, of 0.0046 in. must be provided between the perforation and the radial-tooth face before the film can be stripped off tangentially without interference.

*9. Advance of Film of Maximum Shrinkage.* The amount that film of maximum shrinkage will advance with respect to the tooth in traveling from the midpoint to the end of the arc of engagement will be essentially $A = e(1 - \cos \alpha)$. This must be equal to or greater than the clearance, $c$, computed above. If, in the case of the 25-tooth sprocket, $A$ is made 0.006 in. to provide some margin, then $\alpha = 60°$.

*10. Advance of Unshrunk Film.* The amount that film of zero shrinkage will advance with respect to the tooth in traveling from the beginning to the end of the arc of engagement will be essentially:

$$A_0 = e(1.5708 + 0.01745\,\alpha - \cos \alpha).$$

In the present example, $\alpha = 60°$, so that unshrunk film will have advanced by 0.0253 in. by the time the stripping point is reached.

*11. Thickness of Teeth, T.* The thickness of the teeth cannot be greater than the difference between the height of the perforation and the amount that unshrunk film advances with respect to the face

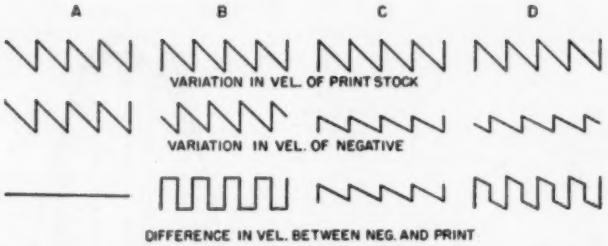



**Fig. 9. Dependence of flutter introduced by printing operation on amplitude and phase of individual negative and print stock velocity variations: A — equal amplitude, in phase; B — equal amplitude, 180° out of phase; C — unequal amplitude, in phase; D — unequal amplitude, 180° out of phase.**

of the tooth. The 16-mm perforation is 0.050 in. high, so that the tooth thickness, $T$, must not be more than 0.050 − 0.0253 = 0.0247 in., in the present example. Actually, a value of $T$ = 0.020 in. was used.

*12. Tooth Profile.* Apart from the required height of the radial face of the tooth and the permissible thickness at the base, the tooth profile is quite arbitrary. A suggested procedure is to cut an involute tooth of thickness $T + c$ at the base, and then cut the radial face on the tooth to a height of $h$ and a tooth thickness of $T$ at the base. Such a tooth is sketched in Fig. 8B. Actually, the radial face is never used below approximately the midpoint, where film of maximum shrinkage bears against it while it is being driven, so that the corner at the base need not be sharp but can be left rounded, as shown in the figure.

*13. Theoretical Flutter.* As was shown in Fig. 7, the effective tooth velocity is a cosine function of the rotation, and the change in velocity is most rapid when $\theta = 90°$. In this region, the percentage change in velocity during one pitch length of travel is given by:

$$\Delta V = s \sin \frac{360°}{N},$$

where $s$ is the film shrinkage in per cent which is accommodated in this region, and $N$ is the number of teeth on the sprocket. For the 25-tooth sprocket designed for a maximum shrinkage of 1%, the change in velocity would be 0.25%. This is the total or peak-to-peak change in velocity, and, since the change is almost exactly linear, the peak deviation from the mean velocity would be 0.125% and the rms deviation or theoretical flutter would be 0.072%. At lower values of shrinkage, the flutter would be less than this value, and at zero shrinkage ($\theta = 0°$) it would be substantially zero.

## Sprockets for Printing

*1. Shrinkage Range for Print Stock.* In the foregoing discussion, consideration was given to the propulsion of only one film. In a contact printer, the print stock is at a greater radius than the negative by one thickness of film. In the present example, the film thickness is 0.5% of the sprocket radius, and therefore the pitch range for the print stock would be from 0.5% long to 0.5% short. Actually, in order to drive film of 0.5% stretch, it would be necessary to increase the height of the radial driving face of the tooth by one thickness of film, and this might require a reconsideration of the other design factors. If one is content with a pitch range of zero to 0.5% shrinkage for the print

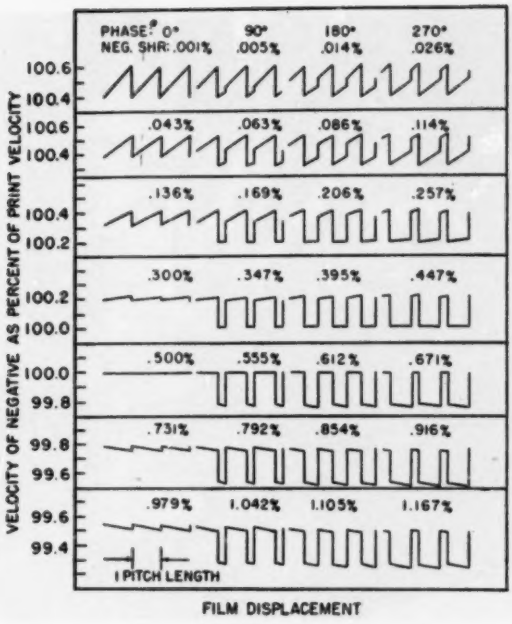



**Fig. 10. Theoretical waveform of flutter introduced into print by printing operation as a function of negative shrinkage.**

*** Phase of negative velocity variation relative to print stock velocity variation. Print stock shrinkage = zero.**

stock, no modifications whatever need be made in the sprocket. In optical printing, each film would be propelled by a sprocket especially designed for the shrinkage range it was required to accommodate.

*2. Flutter in Printing.* Theoretically, in either a contact or an optical printer, each film would experience a saw-toothed velocity variation, as explained earlier. Conceivably, these velocity variations could be of the same amplitude and exactly in phase so that the net velocity between the films would be zero at all times. This would occur in a contact printer, for example, when both films were being driven by the same tooth at every instant, and in that case the printing operation would theoretically introduce no flutter into the print. This condition is illustrated in Fig. 9A. If, however, the amplitudes and/or phases are not equal, as in Figs. 9B, 9C and 9D, then the instantaneous velocity difference will determine the flutter introduced by the printing operation.

In Fig. 10 are shown a family of theoretical print flutter waves for the 25-tooth, 16-mm sprocket when used for contact printing. The print stock is considered to have zero shrinkage, and the waveforms are shown for various negative shrinkages of from zero to 1.1% as the driving point for the negative changes by $\frac{1}{4}$-pitch-length (90°) intervals relative to that of the print stock. From the figure and from the data in Table II, it can be seen that the peak-to-peak flutter introduced in the print never exceeds the larger of the peak-to-peak velocity variations in the individual films. The worst conditions are those in which the individual velocity variations of the two films are out of phase by one-half pitch length (180°) and the amplitudes are substantially equal. In these cases, the flutter in the print is of substantially square wave-

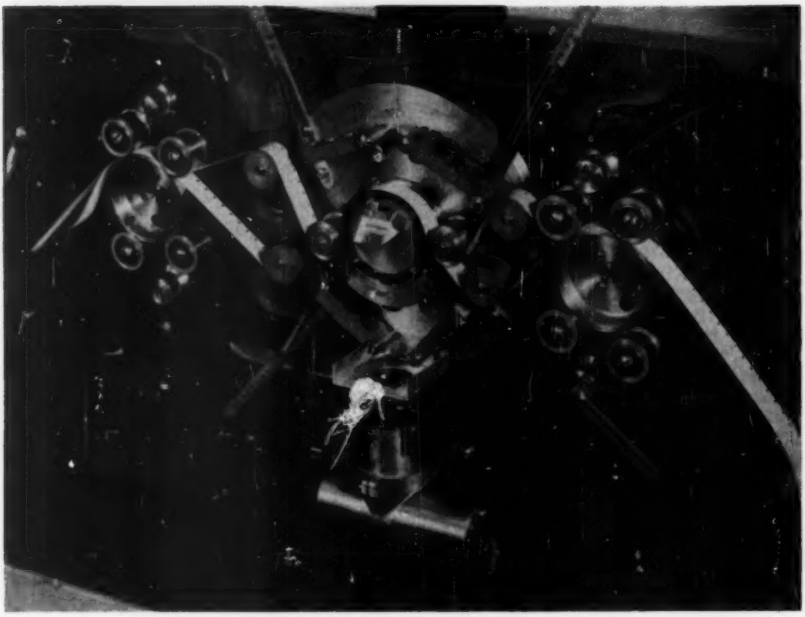


**Fig. 11. Radial-tooth, variable-pitch sprocket assembly on experimental 16-mm printer.**

**Table II. Theoretical Flutter vs. Negative Shrinkage in 16-mm Contact Prints Made on a 25-Tooth Radial-Tooth Variable-Pitch Sprocket. Shrinkage of Print Stock, Zero**

| Phase angle, deg | Negative shrinkage, % | rms velocity deviation, % |
|---|---|---|
| 0 | 0.001 | 0.059 |
| 180 | 0.014 | 0.072 |
| 0 | 0.043 | 0.042 |
| 180 | 0.086 | 0.086 |
| 0 | 0.136 | 0.029 |
| 180 | 0.206 | 0.108 |
| 0 | 0.300 | 0.008 |
| 180 | 0.395 | 0.102 |
| 0 | 0.500 | 0 |
| 180 | 0.612 | 0.116 |
| 0 | 0.731 | 0.014 |
| 180 | 0.854 | 0.124 |
| 0 | 0.979 | 0.020 |
| 180 | 1.105 | 0.125 |

form and the peak and rms velocity deviations are substantially identical and equal to 0.125%.

*3. Picture Steadiness.* It is readily apparent that picture unsteadiness introduced by a printer is not caused by differences in velocity which repeat every pitch length, but is caused by erratic differences in velocities which are unpredictable. Repetitive velocity differences only cause an undetectable vertical distortion of the image and possibly a slight loss in definition in local areas.

### Experimental Contact Printer

An experimental 16-mm printer was modified to use a 25-tooth sprocket of the above design. Figure 11 is a photograph of the printer. The printing

sprocket is a thin wafer of tool steel. On either side are the decentered film-supporting drums. Feed-on and feed-off rollers are located so that the film has a wrap of 150° between tangent points. Tension rollers and arms are made as light as possible through the use of magnesium and are spring-loaded to keep the films against the driving faces of the teeth and to keep the films in good contact.

The sprocket itself was cut by using a special fly-cutter on a precision hobbing machine. The hub of the sprocket was provided with four adjusting screws so that it could be accurately adjusted for concentricity after it was mounted on the printer. Concentricity was checked in the manner illustrated in Fig. 12. The sprocket was rotated so that each tooth in succession rested against the end of a brass spring disposed normal to the radial-tooth face, while, diametrically opposite, the position of another spring substantially parallel to the tooth face was measured with a microscope. By this means, virtually all trace of eccentricity was eliminated. An ellipticity of approximately 0.0001 in. remained, about which nothing could be done.

The film-supporting members were made of tool steel, hardened, polished and chrome-plated. Negatives are cleaned and waxed frequently.

Since in a shrinkage-accommodating printer of this type slippage between the films is not eliminated but only made as uniform as possible, it is imperative that the exposing aperture be made as small as possible lengthwise of the film to avoid loss of definition. For example, if there is a difference in velocity of 0.5% between the two film surfaces, then in traveling past a 0.1-in. aperture the films would creep 0.0005 in., an amount which would theoretically obliterate a 7200-cycle wave on 16-mm film. In the experimental printer, a cylindrical lens was used to reduce the aperture to approximately 0.020 in.

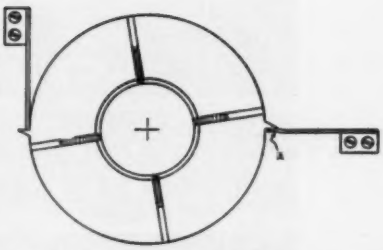



**Fig. 12. Setup for adjusting concentricity of sprocket. Position of a point on spring at A is measured with a microscope normal to diagram.**

### Testing Procedure

*1. Sound Tests.* In order to test the effectiveness of the sprocket for printing sound, a series of flutter negatives was recorded on a high-quality, drum-type recorder on stock which had been perforated to a series of pitches to simulate films of from zero to 1% shrinkage. The negatives were exceptionally free from 24-cycle flutter, although some low-frequency disturbance was present. Since the printer would be expected to introduce principally 24-cycle and higher disturbances and no low-frequency disturbance, the flutter in the negatives and prints was measured using a flutter meter adjusted to read the flutter in the 10- to 300-cycle band only. A flutter-free sprocketless reproducer with a 15-in. viscously driven flywheel was used in reproducing the films.

In Fig. 13 are shown fluttergrams on the test negatives and in Fig. 14, those on a typical set of prints. Shrinkages indicated are those at the time of printing. Flutter percentages recorded on the charts are readings of a rectifier-type meter calibrated to read rms values on sinusoidal waves. The periodic variation in amplitude in the print fluttergrams is probably caused by the slight ellipticity in the sprocket.

In Fig. 15 is shown a set of flutter-

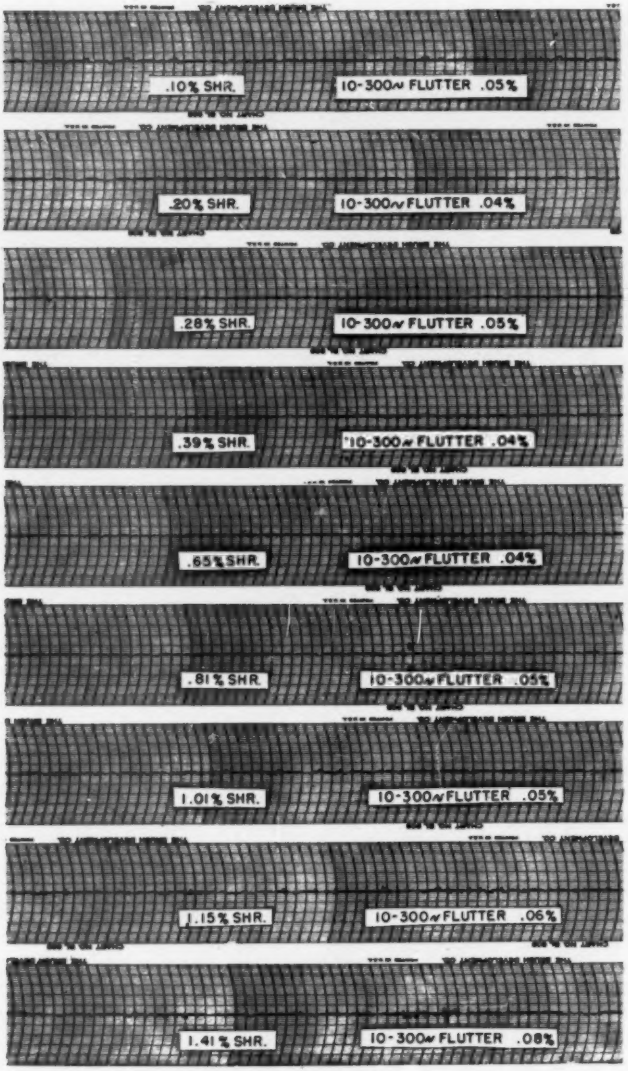



**Fig. 13. Fluttergrams of 3000-cycle/sec flutter-test negatives.**

grams on a similar set of prints made on a commercial 16-mm printer. The reduction in recorder sensitivity for the three prints from the negatives of maximum shrinkage should be noted.

*2. Picture-Steadiness Tests.* In order to test the printer for picture steadiness, a set of test negatives was exposed on a step-printer mechanism which could be used both as a camera and as a projector.

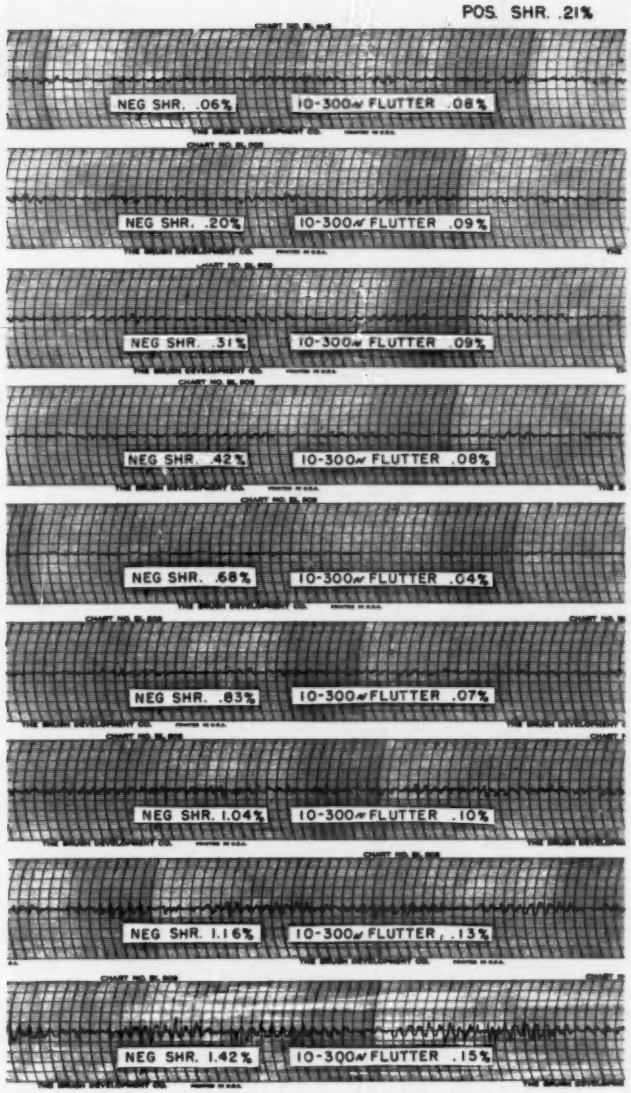



**Fig. 14. Fluttergrams of contact prints made on radial-tooth, variable-pitch sprocket.**

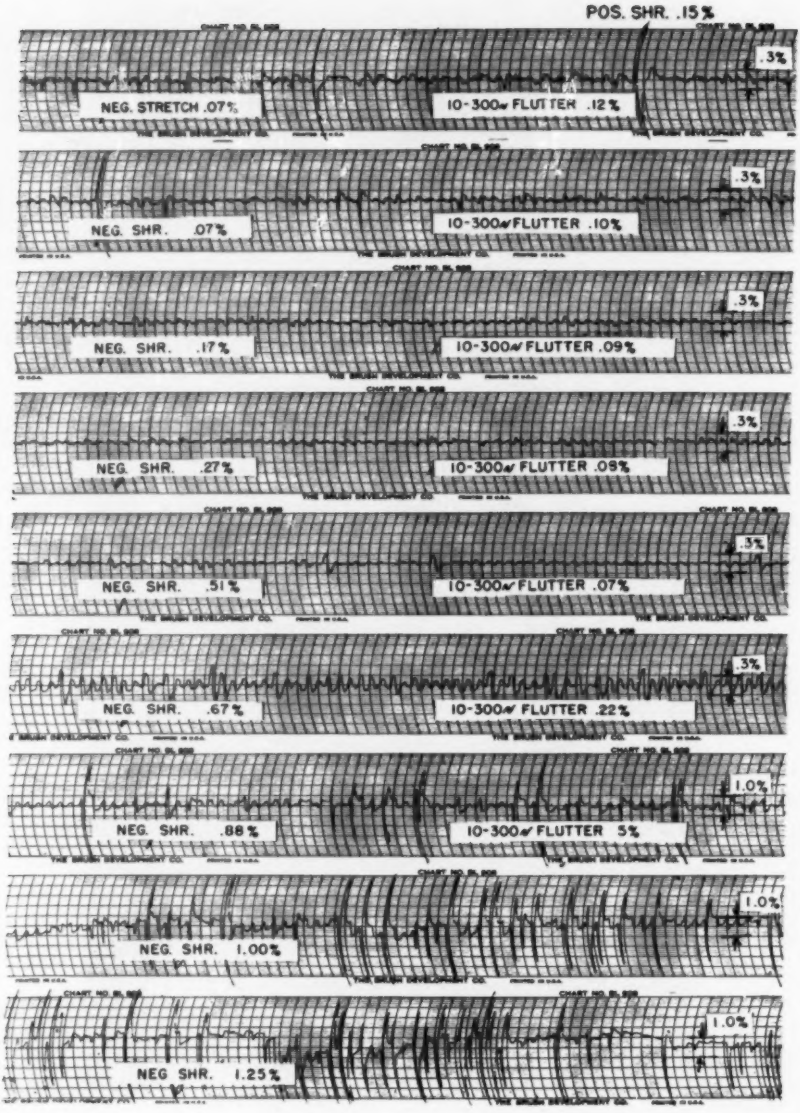



**Fig. 15. Fluttergrams of contact prints made on conventional commercial 16-mm contact printer.**

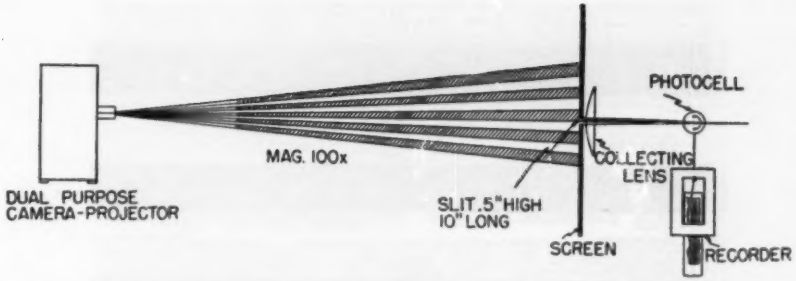



**Fig. 16. Schematic drawing of setup used for recording picture steadiness.**

As in the case of the sound tests, exposures were made on stock perforated to simulate shrinkages of from zero to 1%. The film was registered in the step printer by means of a registration pin whose position relative to the pull-down claw was adjustable, depending on film pitch.

The image exposed on the film consisted simply of a grid of clear and opaque horizontal bars. Such a pattern is well suited both to subjective steadiness observations and to physical measurement of image motion. Unsteadiness introduced by continuous contact printers usually exhibits itself as vertical motion of local areas of the image, rather than of the entire frame. This produces a rubbery image.

The setup used for making physical measurements of steadiness is shown in Fig. 16. The grid-type image on the film is projected onto the screen so as to eclipse part of a narrow horizontal slit in the screen. A collecting lens directs the light passing through the slit onto a photocell connected to a d-c amplifier and a Brush graphic recorder. Since the shutter in the projector interrupts the light once per frame, the recorder records a series of pulses, one for each frame, the amplitudes of which depend on the vertical position of the successive images on the slit. The whole system is adjusted so that a change in pulse amplitude of 1 cm represents an image motion of 0.001 in. at the projector gate.

Figure 17 shows steadiness charts, made as described above, on the series of negatives of various pitches. Since these test negatives were exposed and projected on the same mechanism, the registration was consistent, i.e., the same perforation was used to register a given frame during projection as during exposure. This type of check is, therefore, mainly one on the consistency of the exposing and projection mechanism. Since the charts show an unsteadiness of only about $\pm 0.0001$ in. from the mean position, the reliability of the step-printer mechanism for exposing negatives and projecting prints is demonstrated.

If, now, the test negatives are projected in the reverse direction from that in which they were exposed, charts of the type shown in Fig. 18 are obtained. In this case, each frame is registered by a perforation five frames removed from the one used in exposure. This comparison demonstrates the importance of using consistent registration in all the operations to which a film is subjected, if the ultimate in image steadiness on the screen is to be achieved.

In continuous printers using variable-pitch sprockets, the perforation or perforations by which a given frame is registered, during the time it is being printed, depends on the shrinkage.

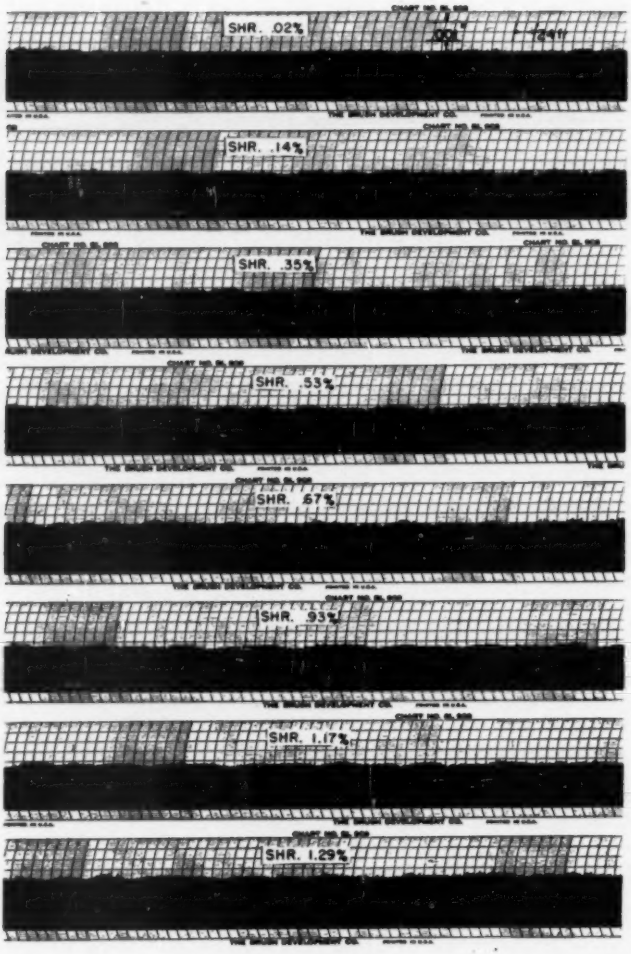



**Fig. 17. Steadiness recordings of picture test negatives; consistent registration during exposure and projection.**

This is true of both negative and print stock and, therefore, two inconsistencies in registration occur between camera exposure and print projection, each of which contributes to the unsteadiness of the projected image. The total unsteadiness is thus caused, in part, by these inconsistencies in registration and, in part, by poor longitudinal positioning of one or both films by the sprocket, as explained earlier. Good printer design can contribute to a reduction of only the latter source of unsteadiness.

In Fig. 19 is shown a series of steadiness graphs on prints made on the

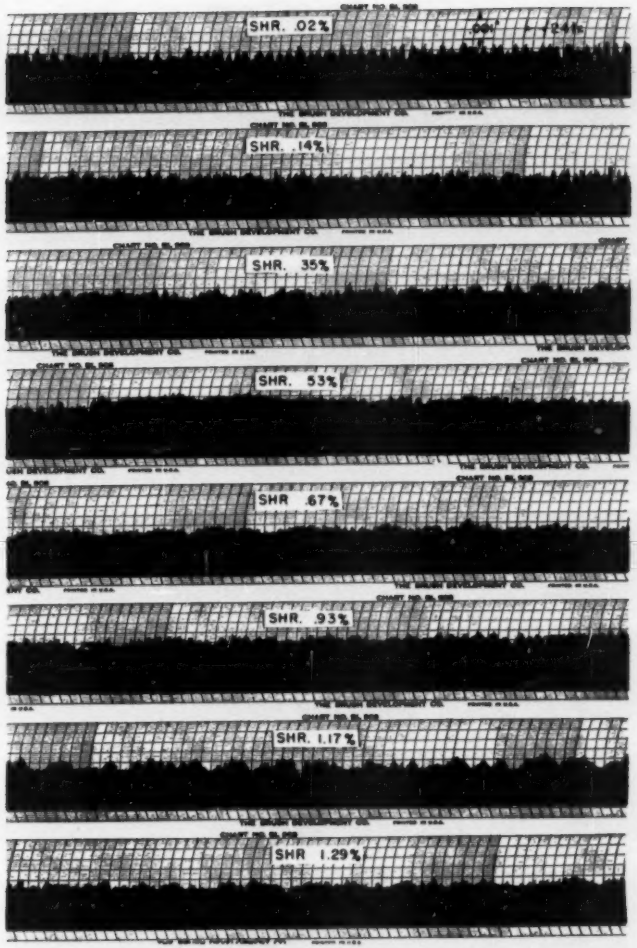



**Fig. 18. Steadiness recordings of picture test negatives; registration during exposure and projection inconsistent.**

radial-tooth sprocket from the test negatives. The graphs indicate that the sprocket is capable of making equally good prints, regardless of negative shrinkage, up to a shrinkage of 1.30%. If drift is discounted, the unsteadiness is seen rarely to exceed ±0.00025 in.

For the purpose of comparison, a similar set of prints was made on a conventional commercial 16-mm contact printer. These are shown in the graphs of Fig. 20. Both the rate and the amplitude of unsteadiness are seen to depend markedly on the negative shrinkage.

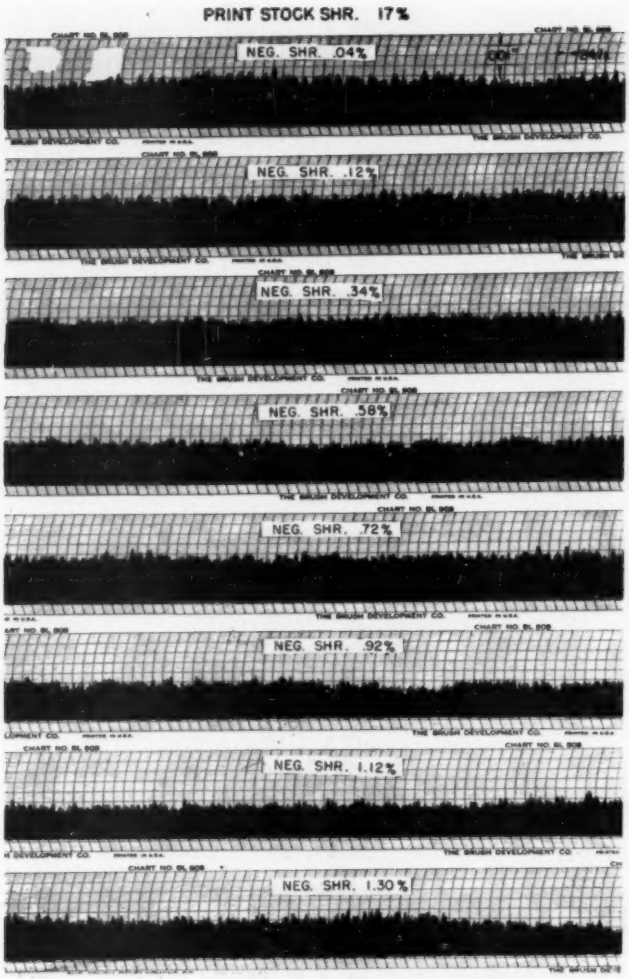



**Fig. 19. Steadiness recordings of contact print made on radial-tooth, variable-pitch sprocket.**

**Other Applications**

The variable-pitch, radial-tooth sprocket can undoubtedly be used to advantage in other applications. Optical printing would presumably benefit to about the same degree as contact printing. In this case, two precision sprockets, preferably on the same shaft, would be required, but each would be designed for optimum performance in the shrinkage range it had to accommodate.

In general, such sprockets designed for sound recorders or reproducers

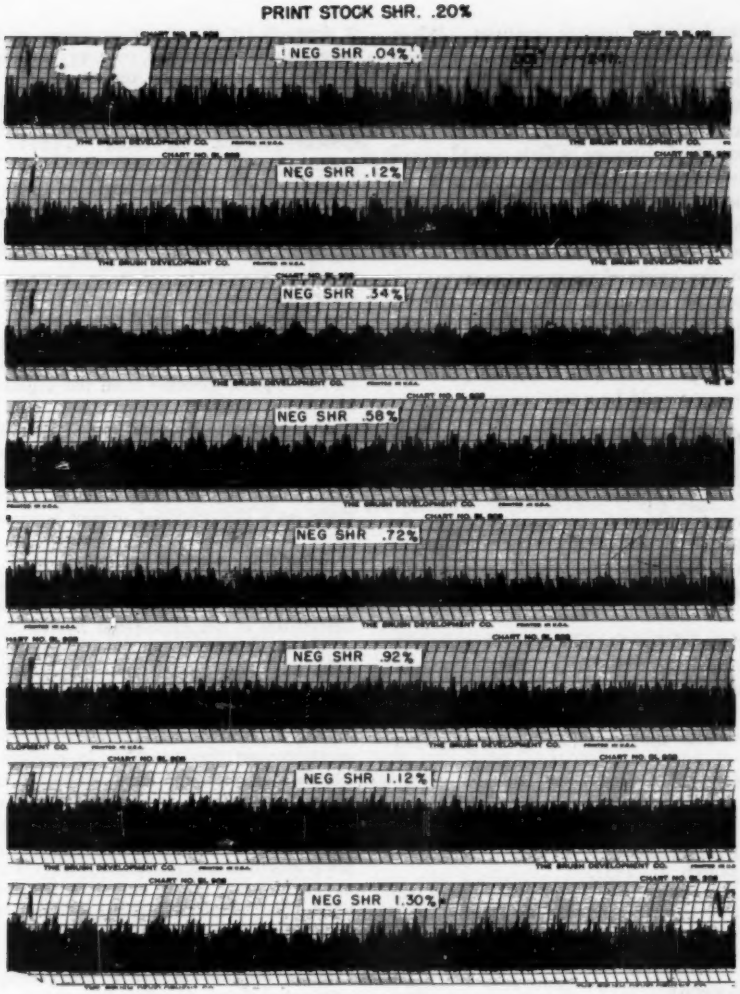



**Fig. 20. Steadiness recordings of contact prints made on a conventional commercial 16-mm contact printer**

would be larger in diameter than conventionally used drum drives. It is believed that filtered drives for such sprockets could be designed which would be substantially free of wow and which would be much more reliable and easier to maintain than drum drives.

High-speed continuous cameras and projectors would be improved markedly by such a sprocket, it is believed.

It might be thought that a shrinkage-accommodating printer, such as the one described, might be used to expose short-pitched duplicate negatives from

normal-pitched master positives. While it might be possible to design a sprocket which would accommodate the pitches involved, the procedure is not to be recommended because of the large amount of slippage which would occur between the films. If, however, a printer were equipped with an auxiliary lamphouse so that the films could be illuminated either from the outside or from the inside of the sprocket, then such duplicate negatives could be made by running the normal-pitch master positive on the outside and the short-pitch duplicate negative stock on the inside, and the slippage would be a minimum.

## Conclusions

The radial-tooth, variable-pitch sprocket appears to offer a comparatively simple and inexpensive means for improving the performance in many forms of equipment which require uniform film motion.

*Acknowledgment.* The author gratefully acknowledges the many helpful suggestions of Dr. Otto Sandvik and Dr. J. S. Chandler made during the course of this work and the preparation of this paper.

## References

1. L. A. Elmer, U. S. Patent 2,122,458, June 30, 1936.
2. E. Mechau, U. S. Patent 1,873,778, March 27, 1931.
3. J. S. Chandler, "Some theoretical considerations in the design of sprockets for continuous film movement," *Jour. SMPE*, vol. 37, pp. 164–176, Aug. 1941.

## Discussion

*Mr. F. Eich:* Can radial-tooth sprockets of larger diameter than the 25-tooth sprocket described in your paper be designed?

*J. G. Streiffert:* Yes, somewhat larger. It depends on the shrinkage range to be accommodated and the velocity variation (flutter) which can be tolerated. For a given shrinkage range, the working height of the tooth is directly proportional to the sprocket radius. In order to have a practical tooth thickness, it would be necessary to reduce the angle of wrap so that there would be about the same number of pitch lengths in the arc of engagement, as in the case of the 25-tooth sprocket described. That is, instead of using the whole 180° arc, you perhaps would use only 90° total arc.

*Anon:* Have measurements of high-frequency loss been made on prints made on this type of sprocket from the negatives of various pitches?

*Mr. Streiffert:* No, we are doing that just now. We expect that the amplitude modulation in a constant-frequency print will be substantially less than in a print made on a conventional printer when the pitch differential is unfavorable.

*Author's note added at publication time:*

It should be emphasized that slippage between films having a large shrinkage differential is not eliminated by this type of sprocket, but is only made relatively uniform. This means that the printing aperture must be kept narrow enough (approximately 0.020 in.) so that the slippage which occurs between the films as they pass the aperture is negligible. The slippage between films of large shrinkage differential is usually quite nonuniform on conventional sprockets. The films stick together for a substantial part of each pitch length of travel and then slip relative to each other more or less instantly. Since the printing aperture is usually 0.100 in. to 0.300 in. in height, the definition is seriously degraded during a substantial fraction of each pitch length, while the remainder of each pitch length has good definition, because no slippage occurred while it was being printed. This results in a large amount of amplitude modulation in addition to frequency modulation (flutter).

# Carbon Arcs for Motion Picture Studio Lighting

By W. W. LOZIER and F. T. BOWDITCH

**A description is given of the technical characteristics of carbon-arc lamps which make them outstanding for motion picture studio lighting. These include penetrating power, covering power, shadow sharpness and spectral properties of the radiation. These are considered in relation to the requirements of various types and sensitivities of color film.**

THE UNIQUE and important properties of carbon-arc lamps which have made them so essential for studio lighting are well known among professional motion picture studio people.[1] However, the technical bases underlying some of these aspects and their quantitative magnitudes have not been so widely recognized. The recent introduction of faster color films and of films which have been balanced for a lower color temperature, makes an appraisal of motion picture studio lighting with carbon arcs appropriate at this time.

The merits of carbon-arc lamps are recognized among cinematographers and other personnel of the motion picture studios in such nontechnical terms as their superior ability "to penetrate deep sets," "to cut through general set illumination," "to produce modeling effects," "to simulate single-source-lighting," "to produce sharp shadows" and "to provide cool light." It will be shown that these features are attributable to tangible, technical characteristics which are measurable in numerical terms. Penetrating power, covering power, shadow sharpness and luminous efficiency are the related technical properties of lamps and radiation which will be discussed in this paper.

Figure 1 is a diagram of the optical system of a typical carbon-arc spot lamp.[2] A Fresnel lens is mounted so that it may be positioned over a range of distances from the positive carbon crater, with a maximum limit close to the focal length of the lens. This lens directs the light into a diverging beam with a spread dependent upon the lens position, and increasing as the lens is moved closer to the crater. The beam spread of present-day carbon-arc lamps ranges from 10–

Presented on October 19, 1951, at the Society's Convention at Hollywood, Calif., by W. W. Lozier, Carbon Products Service Dept., National Carbon Co., Division of Union Carbide and Carbon Corp., Fostoria, Ohio, and F. T. Bowditch, Research Laboratories, National Carbon Co., Division of Union Carbide and Carbon Corp., Cleveland, Ohio.

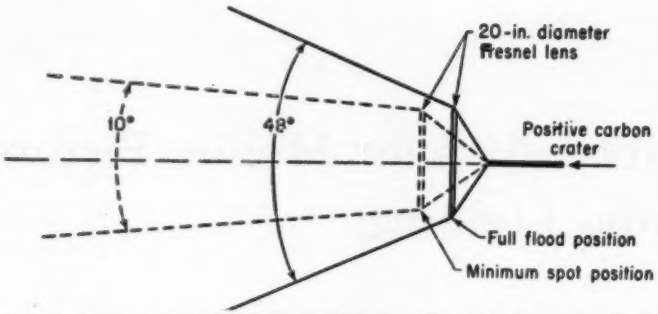



**Fig. 1. Diagram of optical system of Type 170 carbon-arc spot lamp.**

13° at minimum spot, with the lens near its focal position, to 44–48° at full flood, with the lens closest to the arc. As the lens is moved closer, it intercepts a larger cone of light to give a greater total illumination than at the position for minimum spot.

At any given beam spread, the light intensity in front of the lamp decreases with increasing distance approximately in accordance with the inverse square law. It is thus conventional to specify the light output for a given condition in terms of a beam candle-power value which can be divided by the square of the distance from the lamp to give the light intensity which will be produced at a position in the beam. Such data, supplied by the Mole-Richardson Company, are given in Table I for the three most popular carbon-arc spot lamps.[3] The greater concentration of the beam at minimum spot more than offsets the smaller light collection and results in much greater beam candlepower than at wider beam spreads. This higher candlepower is, of course, effective over a much smaller angle.

The color quality of the light from high-intensity carbon arcs is suitable directly or with only minor filtering for photography with color films balanced for daylight. With film balanced for lower color temperatures, a greater proportion of red than green, and of green than blue light is needed, so that a white-light source must have a great deal of its blue and green content removed when used with such a film. For instance, with a blackbody at 3350 K, the green content is about twice, and the red content three times, that of the blue. In order to match this radiation, a white-light source, or one with approximately equal energy at all wavelengths, requires a filter which will dissipate at least two-thirds of the blue and one-third of the green radiation present in the source — a theoretical loss averaging about one-third. The present state of the art with

**Table I. Characteristics of Carbon-Arc Studio Lamps**

| Lamp | Light source, carbon | Fresnel lens diam., in. | Beam Spread | For 10% of center intensity | For 50% of center intensity | Apparent candlepower at center of beam | Beam lumens* | Approx. apparent source size, in.† Visual | Photometric |
|---|---|---|---|---|---|---|---|---|---|
| Type 450 "Brute" | 225-amp, 16-mm | 24 | Min. spot | 12° | 5° | 10,000,000 | 117,000 | 23.5 | 13.3 |
| | | | Full flood | 48° | 35° | 1,000,000 | 260,000 | 4.1 | 3.4 |
| Type 170 | 150-amp, 16-mm | 20 | Min. spot | 10° | 4.4° | 5,700,000 | 47,000 | 19.5 | 9.7 |
| | | | Full flood | 48° | 42° | 300,000 | 130,000 | 1.8 | 1.2 |
| Type 90 | 120-amp, 13.6-mm | 14 | Min. spot | 10° | 5° | 2,040,000 | 18,700 | 13.3 | 6.9 |
| | | | Full flood | 44° | 43° | 130,000 | 62,500 | 1.8 | 1.3 |

* Boundary intensity 10% of center intensity.
† Horizontal dimension as viewed visually and photometrically from the beam through the Fresnel lens.

respect to particular color films is defined in the following paragraphs.

*1. 150 Foot-Candle Film Balanced for 3350 K.* For the purposes of this discussion, it has been assumed that a deep amber filter of approximately 50% foot-candle transmission will adapt the carbon-arc illumination to this type of film.* This is characteristic of the gelatin filter combination presently being used with Technicolor film of this type, although a significantly greater transmission is at least theoretically possible, as indicated previously.

*2. 300 Foot-Candle Film Balanced for Daylight.* It has been assumed that, in accordance with present studio practice,[1] a light yellow Y-1 gelatin filter of 90% transmission will render carbon-arc lamps suitable for use with this type of film.

*3. 450 Foot-Candle Film Balanced for Daylight.* The filtering here is assumed to be the same as for the preceding case.

**Penetrating Power**

An outstanding feature of carbon-arc studio lamps is the very great beam candlepower of a single unit. This makes possible great *penetrating power*, or the ability to project useful intensities of light from great distances. One advantage of great penetrating power lies in the ability to produce a more even illumination along the useful length of the beam, across the set. If a comparatively weak lamp must be placed close to a set of appreciable depth, the light intensity from this lamp will vary markedly along its path across the set. This effect can be minimized only by using a more powerful lamp at a greater distance so that the depth of the set is a smaller fraction of the projection distances involved. Figure 2 indicates the penetrating power of the different carbon-arc lamps for equivalent photographic effect at the center of the beam, with each of the three types of film described above. It shows the distances at which the lamps, properly filtered, will project 150, 300 and 450 ft-c of illumination for each of the types of color film. With the beam spread adjusted for minimum spot, the indicated intensities can be projected approximately three times as far as when the lamps are adjusted for full flood. At minimum spot, the most powerful lamp can project the indicated intensity more than 180 ft for the 150 ft-c film and more than 170 ft for the 300 ft-c film.

Figure 3 shows the depth of set which can be illuminated within plus-or-minus 20% of the specified light intensity in each case. It is noted that the more powerful lamps and the small beam spreads are required to illuminate sets deeper than 25 ft with this degree of uniformity. Of course, a number of weaker units might be located at a similar distance to produce equivalent uniformity across the set, but this produces multiple shadows which are sometimes objectionable.

**Covering Power**

The photography of many scenes, particularly those involving outdoor lighting, requires that the effect of a single

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* *Note.* Recent filter developments indicate the likelihood of being able to transform carbon-arc-lamp radiation to a quality suitable for 3350 K color films with substantially higher transmission than the 50% value assumed in this paper. This will correspondingly increase the light available from such filtered lamps and will increase the quantities representative of 150 ft-c, 3350 K film plotted in Figs. 2, 3, 4 and 6 by the square root of the ratio of the increase in light output. For example, increasing the filter transmission to 60% instead of 50% would increase the light output of the filtered lamps by 20%, and would increase the penetrating power, the range of projection distance, the covering power and the shadow sharpness for 150 ft-c, 3350 K film by about 10% over the values shown in Figs. 2, 3, 4 and 6.

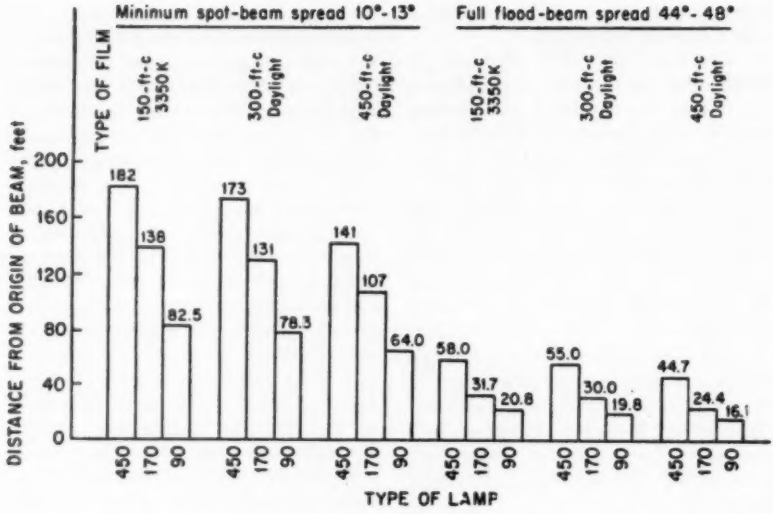


**Fig. 2. Penetrating power (projection distance) of carbon-arc spot lamps for equivalent photographic effect at the center of the beam with three types of film. Allowance has been made for proper color filters.**

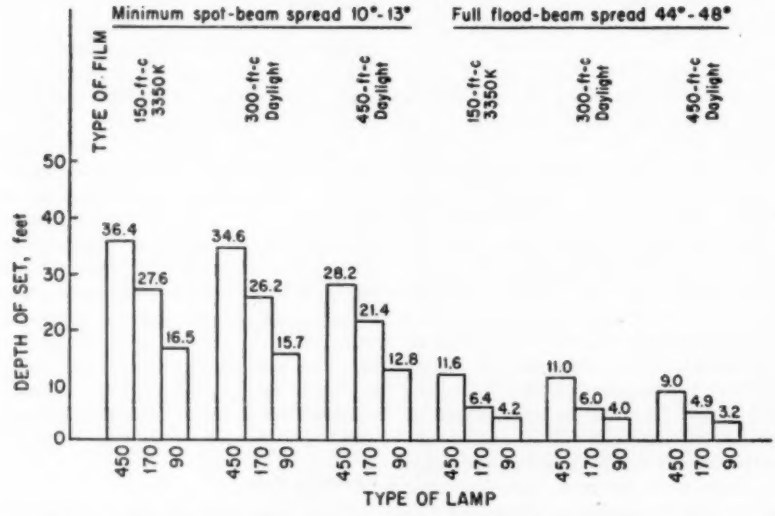


**Fig. 3. Range of projection distance of carbon-arc spot lamps for ±20% variation in intensity. Same conditions as Fig. 2.**

source be produced over a considerable area. In these cases, the area which can be covered with a single lamp is of interest. The ability of a carbon-arc lamp to cover a large area is attributable to the high lumen content of the beam. The area of a set which can be illuminated to a given intensity with a single lamp is definable in terms of the diameter of the spot over which this intensity can be secured. This diameter is called the *covering power* of the lamp for the purposes of this paper, and depends upon the projection distance and the beam spread. The boundary of a projected light beam is conventionally taken as the point where the light intensity is 10% of that at the center. Since more than 10% of maximum intensity may be required for photographic purposes, values of the covering power for boundary intensities 50% of the center value are also given. Figure 4 shows the covering power so defined for the carbon-arc lamps and the film conditions considered in the preceding charts. The total height of each block indicates the covering power with a 10% boundary intensity; the horizontal line across each block at a lower value indicates the covering power of the same source, but with the 50% boundary intensity. The lamps at minimum spot can cover set widths from 10 ft to 40 ft on the basis of a 10% boundary intensity. For a 50% boundary intensity, the minimum spot coverage is approximately half as great.

The covering power at full flood is substantially greater than at minimum spot, on account of the greater lumen output at the flood position. Also, the covering powers for the 50% and 10% boundary intensities are more nearly identical at full flood, as a result of the more uniform distribution across the wider beams.

It will be noted that the areas which can be illuminated to a given intensity will depend on the square of the corresponding beam diameters shown in Fig. 4. These areas cannot be simply specified in a general way, since the beam ordinarily strikes the set at an angle determined in each case by the effect wanted.

**Sharpness of Shadow**

Figure 5 illustrates the formation of a shadow by a light source. The sharpness of the shadow is determined by the source size and its distance from the object, these in turn fixing the angle subtended by the source at the shadowed object; the smaller this angle, the sharper the shadow. It is a characteristic of the Fresnel lens optical system at full flood that only a small portion of the lens area is effective in directing light to a particular object in the beam. As the lens is adjusted toward the minimum spot position, this effective area increases. Therefore, shadows of objects placed at the same distance from a given lamp will be sharper when the lamp is adjusted for full flood than for minimum spot.

The effective horizontal dimensions of the sources for the extremes of beam spread were measured for each lamp with the results shown in Table I. These were determined both visually and by recording with a photocell the intensity variation across the shadow formed by an opaque straight edge. The latter determinations were based upon the width of shadow between the points at which the light intensity was 10% and 90% of the unshadowed intensity. The source sizes so determined were found to be smaller than those visually observed, as shown in Table I, and are believed to be a better measure of photographic shadow sharpness. The edges of the luminous spot on the lens surface are not sharply defined, the light tapering downward over a bandwidth which is difficult to define with the eye alone. Thus, although the entire area of the Fresnel lens appears visually luminous when set for minimum spot, much of the outer area is of relatively low brightness and is essentially ineffective in contributing to the shadow formation.

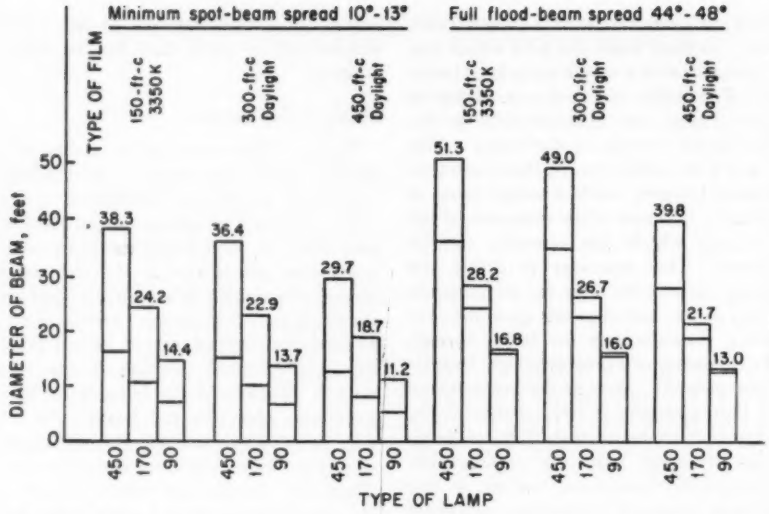


**Fig. 4. Covering power (diameter of beam) for carbon-arc spot lamps for same conditions as Fig. 2. Upper and lower values correspond respectively to intensities at the beam boundary of 10% and 50% of center intensity.**

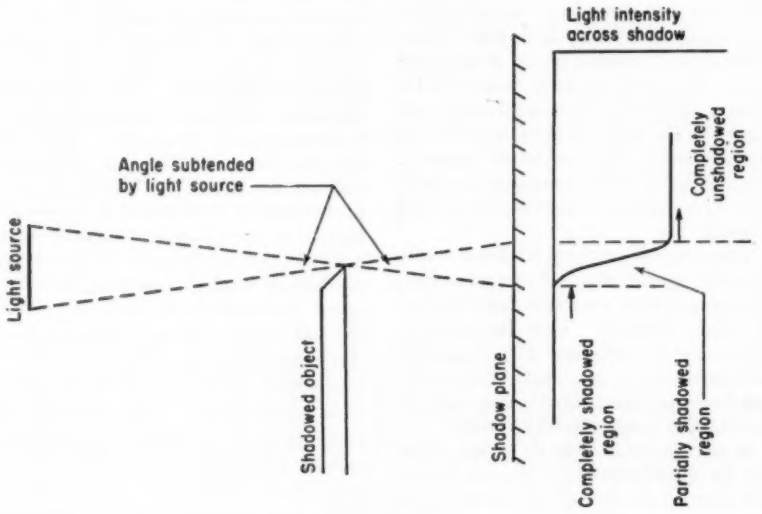


**Fig. 5. Diagram showing how sharpness of shadows depends on angle subtended by the light source at the shadowed object.**

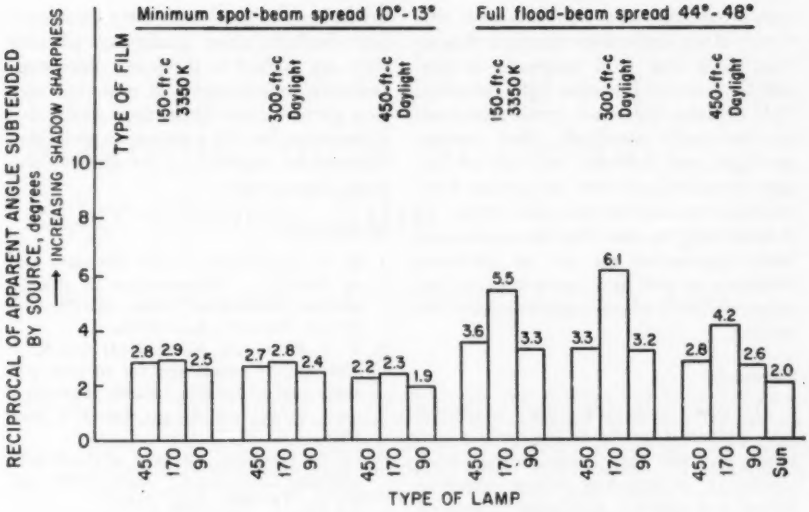


**Fig. 6. Shadow sharpness from carbon-arc spot lamps for same conditions as Fig. 2.**

In order to secure a measure of shadow sharpness which increases with increasing sharpness, the reciprocal of the subtended angle, measured in degrees, has been chosen. This reciprocal value is shown in Fig. 6 for the lamps and films under consideration. For comparison, the value of 2.0 which measures the sharpness of shadows produced by the sun is included. Values higher than 2.0 indicate shadows sharper than those of the sun, while lower values give more fuzzy shadows.

It will be noted that all the carbon-arc lamps at all conditions shown in Fig. 6 produce a shadow sharpness essentially equivalent to or sharper than the sun. As previously indicated, markedly sharper shadows are produced at full flood than at minimum spot. It is the small source size and the high brightness of the carbon arcs which allow them to produce useful intensities of radiation with a shadow sharpness surpassing that obtained from the sun and from other studio-lighting sources.

### Heat Per Unit Light

Thermopile measurements of the total radiant energy from the carbon arcs show that the unfiltered lamps have a luminous efficiency of approximately 75 to 100 lm per radiated watt in the light beam. This value is, of course, substantially higher than the lumens per watt of total arc power, since all the input power is not converted to radiation, and all the radiation is not focused into the light beam. Similar measurements using a gelatin filter combination with one "MT-1" and two "Y-1" filters resulted in approximately 50% loss in visual candlepower, but correspondingly reduced the total radiant energy, so that there was only a 10% to 20% loss in luminous efficiency. This filter combination is the one presently used with carbon arcs and 3350 K film. Incandescent tungsten lamps used for studio lighting are reported to have a luminous efficiency of 35 to 40 lm per radiated watt.[4] With or without the gelatin filter combi-

nation on the arcs, the luminous efficiency of the carbon-arc lamps is thus at least twice that with tungsten, to give half the heat for the same light intensity. This explains the much greater coolness conventionally associated with carbon-arc light, and indicates that this advantage is maintained with the gelatin filter combination and the new color films. It is interesting to note that the carbon-arc lamp approaches the sun in luminous efficiency as well as in color quality, the solar efficiency being approximately 100 lm/w.[5]

## Summary

The small source size, high brightness and high unit power of the carbon arcs make possible their outstanding superiority in penetrating power, covering power and shadow sharpness compared to other available light sources. The daylight quality of the light is responsible for the coolness of the radiation and permits ready interchangeability with daylight in color photography.

It is expected that whether the carbon-arc lamps are used with their characteristic daylight color quality or whether they are filtered to the lower color-temperature requirements of new-type motion picture color films, their distinctive characteristics will continue to give them widespread application for motion picture photography.

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# Magnetic Sound on 16-Mm Edge-Coated Film

By E. E. MASTERSON, F. L. PUTZRATH and H. E. ROYS

**A small head for magnetic recording and reproduction has been developed to fit within the area of the sound drum of a standard RCA-400, 16-mm projector. The head mounting is such that the projector can be used for the two magnetic functions as well as photographic reproduction. The amplifier modifications included increasing the amplifier gain, using various compensating circuits, decreasing the oscillator distortion and means for eliminating the possibility of leaving the record-playback head in a magnetized state. Two switches, mechanically coupled, have been provided to permit the selection of the desired amplifier function.**

Within the past few years magnetic recording has developed to such an extent that it is now recognized as one of the best sound recording means available. It is used extensively in broadcast stations, in disk studios for original recording, and in film recording studios where the sound is recorded magnetically and then transferred by the usual photographic means to prints for theater use. In the first two applications, thin tape, one-quarter of an inch wide, is generally used, but where picture and sound are combined and synchronism becomes necessary, film with sprocket holes is the common medium. Usually 35-mm film is used, it being either coated across the entire surface or only over the picture and sound track areas leaving the sprocket holes uncoated.

With such widespread acceptance it is only logical, therefore, that magnetic recording would be considered for 16-mm usage. An improvement in signal-to-noise ratio is available and a wider frequency response range is believed to be more easily obtainable. Furthermore, a magnetic track allows complete freedom in the choice of photographic emulsion and processing, and in addition, the recording may be put on or changed at any time since there is no processing involved for the magnetic track.

Magnetic sound with picture was demonstrated in 1947 by Camras* using

Presented on May 4, 1951, at the Society's Convention at New York, by E. E. Masterson, Eckert-Mauchly Computer Corp., Philadelphia, Pa. (formerly with RCA Victor Div.), F. L. Putzrath and H. E. Roys, Radio Corporation of America, RCA Victor Div., Camden, N.J.

* M. Camras, "Recent development in magnetic recording for motion picture film," *J. Acoust. Soc. Am.*, vol. 19, pp. 322–325, Mar. 1947, demonstrated at the Acoustical Society Meeting in Chicago, Nov. 15, 1946.

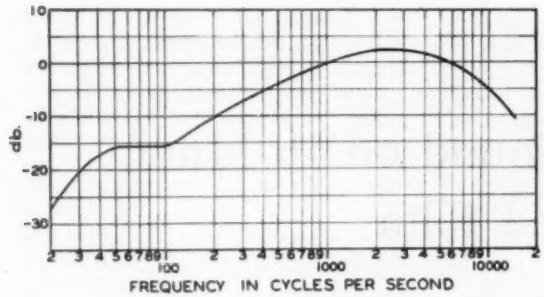


**Fig. 1. Frequency-response characteristic of the small head at a tape speed of 15 inches a second, with constant recording current. The response characteristic of the playback was flat.**

a film that he had edge coated. Schmidt demonstrated some edge-coated 16-mm film, that is now commercially available,† at the SMPTE Convention in the Fall of 1950. The machine used by Schmidt was an RCA engineering model and it is the purpose of this paper to describe that development model.

### General Design Considerations

Existing 16-mm projectors are designed for reproduction of photographic recording, and in most cases, the sound track is scanned at the drum where the film motion is steady and the flutter a minimum. It is the usual practice in magnetic recorders, however, to locate the recording and reproducing heads ahead of the driving capstan, and to depend upon the capstan and a stabilizing flywheel to impart smooth motion to the medium. The capstan in this case corresponds to the sound drum in the sense that the function of both is to impart uniform, flutter-free motion to the medium, although in most projector designs the sound drum is driven by, instead of driving, the film.

Examination of the RCA-400 projector reveals that there is little room to mount a magnetic head either before or after the sound drum without altering the film path and introducing additional idlers and flutter-eliminating devices.

Normally the base side of the film is in contact with the surface of the sound drum so that the magnetic track, being on the base side, would extend beyond the inside edge of the drum. If the head is to contact the film within the drum area it is therefore necessary to locate the head between the shaft and the periphery of the drum. This does not provide much mounting space and it therefore is not attractive mechanically; however, there are certain advantages that must be considered. The flutter should have a minimum value since the film is in contact with the sound drum; in addition, the distance between picture and sound can be maintained the same as for photographic recordings. Although at the time the development was being considered no standards or proposals for the location of magnetic tracks existed, it was believed that an agreement on any different separation between picture and sound would be impossible, since so many projectors of various designs were in existence. Therefore, it appeared wise to try a small head within the area of the sound drum.

### Magnetic Head Development

The projector drum and the shaft are 0.880 and 0.3143 in. in diameter, respectively, which leaves a radial depth of 0.283 in. for the magnetic head, so it became necessary to limit the maximum height of the head to 0.250 in.

† Edward Schmidt, "Modernized commercial sound recording," paper presented on Oct. 19, 1950, at the Society's Convention at Lake Placid, N.Y., with demonstration of film available from Reeves Soundcraft Corp., Long Island City, N.Y.

Fig. 2. Head and mounting assembly.

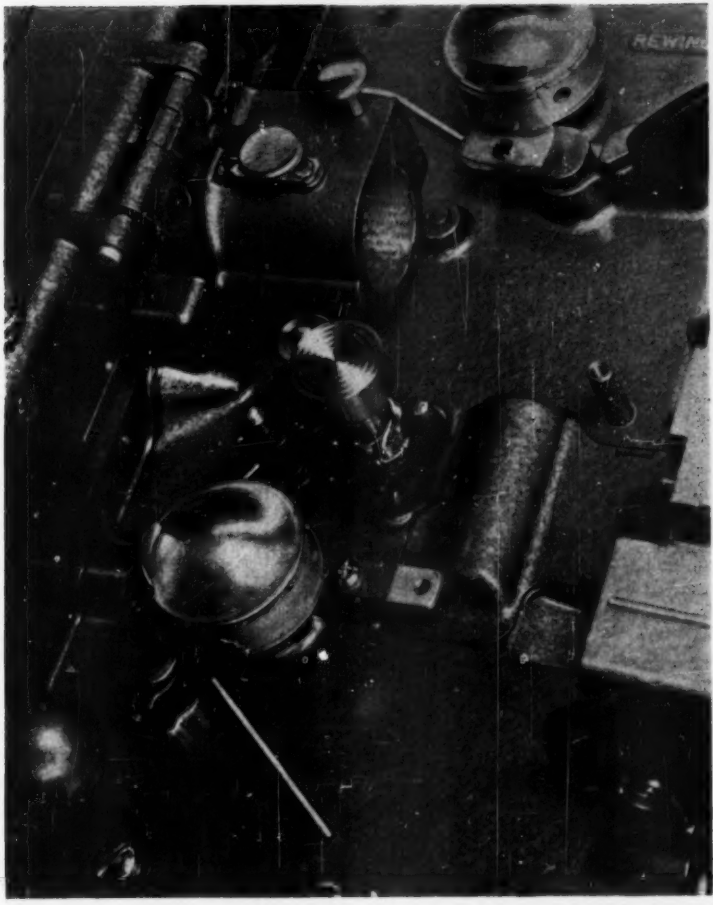

Fig. 3. Head and mounting assembled in place on the Model 400 projector. The sound drum was withdrawn slightly in order to obtain a better view.

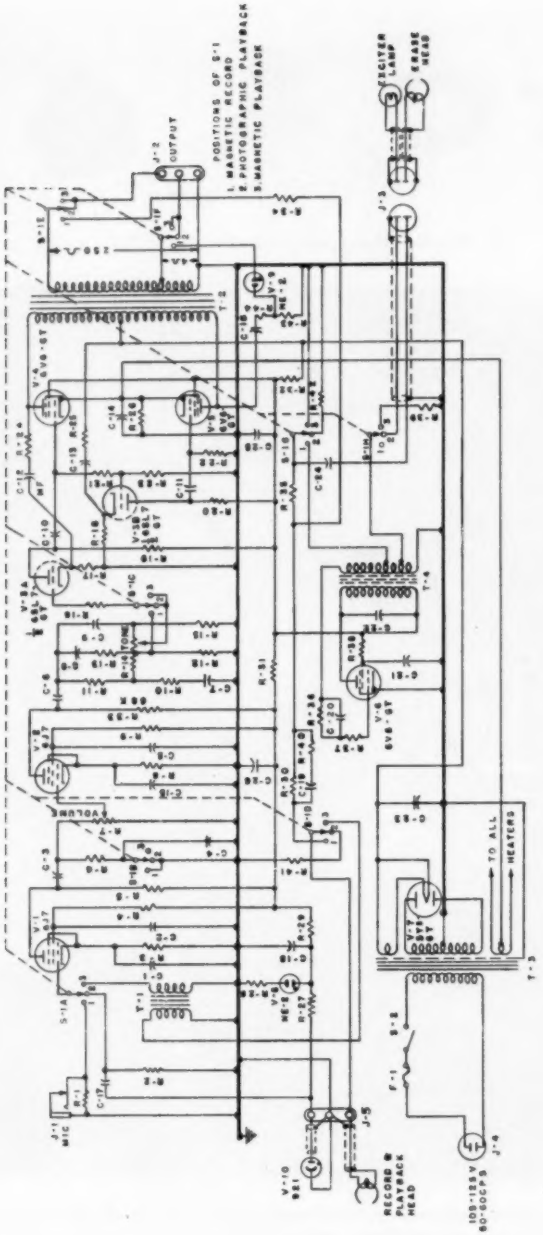


Fig. 4. Circuit of the modified amplifier.

An experimental head was constructed to fit within the allotted space and an engineering demonstration was given during the latter part of 1948. The results were encouraging and further consideration was given to a new design which would incorporate features found desirable during the earlier work.

A small head was designed and extensive tests were made using $\frac{1}{4}$-in. tape operating at 15 in./sec, in order to obtain a comparison with broadcast-type heads. On an equivalent impedance basis the small head showed a 3-db increase in output over a larger ring-type head of conventional design. A frequency-response characteristic with constant current input is shown in Fig. 1. The flat portion or shelf between 100 and 50 cycles is due to the relative physical dimensions of the magnetic structure with respect to the length of the recorded waves. There appears to be no objection to this shelf, in fact there is the advantage of an increase in output at these lower frequencies where hum is usually present. At a medium speed of 7.2 in./sec, which corresponds to the normal 16-mm sound speed of 24 frame/sec, this shelf would be moved downward by an amount proportional to the speed change (15 to 7.2 in./sec).

The head is mounted in a cylindrical housing through which the drum shaft protrudes. Both the magnetic head and the mirror, used for photographic reproduction, are mounted in cutout portions of the cylinder. The cylinder is clamped by means of a ring, and is rotatable to permit positioning of the mirror or the head for either photographic or magnetic operation. Two stops, one adjustable, are provided to limit the rotation of the cylinder. The cylinder is mounted eccentrically with respect to the sound drum to provide a means of adjusting the contact pressure between the magnetic head and the magnetic track. Azimuth alignment is accomplished by rotation of the head within its housing. The magnetic head does not contact the film during photographic reproduction and therefore cannot scratch or mar the sound track and cause noise during playback. The head and mounting parts are shown in Fig. 2, in various stages of assembly. Figure 3 shows the arrangement mounted on an RCA-400 projector.

**Amplifier**

The amplifier modified for this development was the same as used in the standard RCA-400 projector. Normally a phototube is used as the input source although for sound reinforcement purposes the input of the amplifier can be switched to operate from a high-impedance microphone. The amplifier has one pentode and two triode amplifier stages, with a triode phase inverter and two push-pull output tubes that deliver 10 w of audio power into the speaker. Two readily accessible controls are used, one for volume and the other for tone, the latter tilting the frequency response about an 800-cycle center frequency.

In the new amplifier all of the normal photographic reproduction requirements are met, and additional facilities for magnetic recording and reproducing of sound on edge-coated film are provided. A means of erasing has been included so that changes can be made, or the entire film erased for re-recording. Erasing can be accomplished only with the switch in the magnetic recording position.

The signal for the grid of the first voltage-amplifier stage, a 6J7, can be obtained from three different sources (see Fig. 4): a high-impedance microphone for magnetic recording, the phototube for optical playback, and the record-playback head through an input transformer for magnetic playback. The step-up ratio of the input transformer is limited by the resonance of the head inductance with the transformer secondary winding capacitance. The frequency of this resonance is adjusted to fall slightly beyond the useful audio range of the playback system as deter-

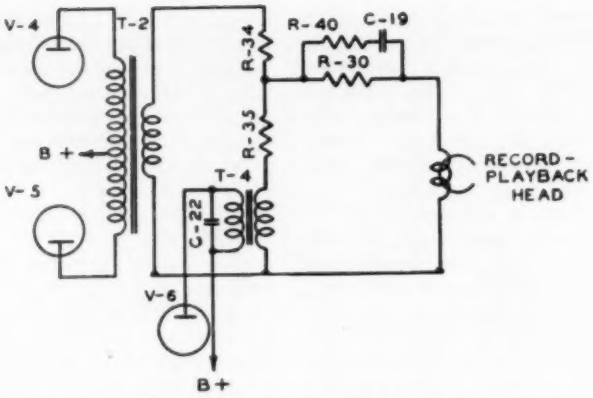


**Fig. 5. Recording circuit for the magnetic head.**

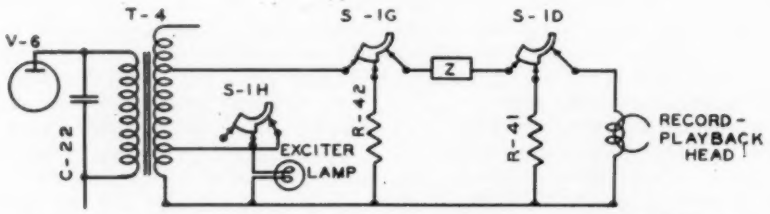


**Fig. 6. Circuit for reducing the bias current at the record-playback head.**

mined by the head gap and the film speed. Although the Q of this resonant circuit is very limited due to the losses in the magnetic head, a 2-db rise at 7.5 kc has been realized.

The plate circuit of the first stage has the necessary low-frequency compensation when the amplifier is used for magnetic playback. During the other two functions this compensation is left out. The volume control is placed here to avoid overloading the low-level amplifier stage when considerable attenuation is used. The subsequent voltage-amplifier stage is a 6J7 followed by the tilt-type tone control. During magnetic recording the tone control action is removed by connecting the following 6SL7-GT grid to the center point of the control resistor.

Two 6V6-GT's in push-pull are used as power amplifiers obtaining their signals from the 6SL7-GT voltage amplifier and phase inverter with overall negative feedback. The feedback loop characteristics are designed to be inherently stable with any type of amplifier loading. The 4-ohm and 250-ohm load windings of the output transformer are used and both are connected to the load jack during either playback function. However, during the magnetic recording the 4-ohm winding is used to complete the connection of the recording level indicator, an NE-2 glow lamp. In the magnetic recording switch position the 250-ohm winding works into a tapped dummy load from which the proper amount of recording current is derived.

The oscillator supplies power to the exciter lamp during photographic playback while during magnetic recording it

supplies current to the recording and erase heads. Because these functions require several watts of high-frequency power, a tuned plate oscillator circuit using a 6V6-GT was selected. Care has been exercised in the oscillator circuit to limit harmonic distortion to amounts which do not adversely affect magnetic recording performance. An oscillating frequency of 50 kc was chosen to be sufficiently above the highest usable audio frequency and yet to keep the losses in the two heads to a minimum. The method of adding the high-frequency recording bias to the audio recording signal is shown in Fig. 5. The resultant signal then goes through the audio pre-emphasis network to the record-playback head. During magnetic playback the oscillator works into a dummy load.

The power supply system does not require special mention except that the phototube polarizing voltage is directly derived from the high-voltage supply and is essentially regulated by another NE-2 glow lamp. This regulation greatly reduces overall gain variations with line voltage fluctuations.

Several problems arise in the design, layout and location of the amplifier and its associated components along the film path. Using the same amplifier for three different purposes requires a careful arrangement of the amplifier components. A single control performs all

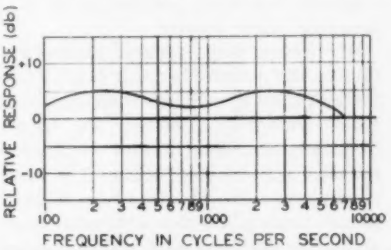


**Fig. 7. Overall frequency response of the magnetic system.**

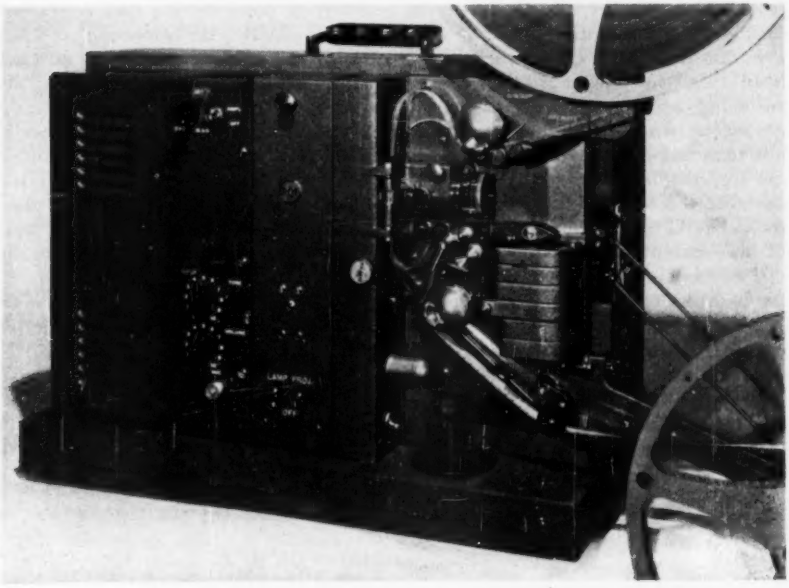

**Fig. 8. The development model of the magnetic recorder.**

necessary switching. Since only one head is used for magnetic recording and reproducing, circuit connections of the amplifier output to the input are involved. To provide some input-output isolation the magnetic recording and playback switch positions are separated and the necessary intermediate switching contacts essentially grounded. The resulting switching sequence permits the use of a mechanical interlock for the magnetic recording position which is a desirable safety feature.

To prevent large residual magnetization of the record-playback head when the amplifier is switched from the magnetic recording position, the high-frequency recording bias on the head is reduced step by step before it is completely removed. Shorting-type switches momentarily place two additional loads across the oscillator and a shunt across the magnetic head. In particular (see Fig. 6), the switch section S-1H connects the exciter lamp, and switch section S-1G adds a dummy load (R-42) to the oscillator; switch section S-1D adds the resistive shunt (R-41) across the head. As any two of these three switching operations will most likely not occur within the time passage of less than one-half cycle of the bias frequency, the bias will probably be reduced in three steps before either switch section S-1G or S-1D interrupts the flow of bias current completely.

Two more problems required attention for satisfactory amplifier performance. A certain amount of oscillator signal is coupled through stray capacities to the low-level amplifier circuits, and during magnetic recording, conductively coupled into the amplifier output circuit. Good wiring practice and circuit arrangement keeps these undesirable signals to levels below which the performance of the amplifier is adversely affected. The other problem encountered was hum pickup in the record-playback head from stray magnetic fields of the power transformer and the projector motor. Shielding and reorientation of these components adequately solves this difficulty.

**Performance**

The overall performance of the final amplifier can be briefly summarized as follows: The amplifier power output is 10 w with less than 3% total harmonic distortion from 100 to 3000 cycle/sec. For photographic sound track operation the amplifier performance remains essentially unchanged. During magnetic recording the film track can be fully modulated with 35 db of attenuation in the volume control without excessive distortion in the first voltage amplifier stage. The amplifier output networks are so adjusted that the 3% harmonic distortion point on the film is reached approximately 3 db before the amplifier begins to overload, thus giving an optimum signal-to-noise ratio during recording. The recording level indicator is adjusted to begin glowing 3 db before film overload is reached. Assuming fully modulated film, the amplifier has about 11-db gain reserve during playback and a noise level 50 db below rated power output with the projector in operation. The overall magnetic record-playback frequency response is flat within 5 db from 80 to 7500 cycle/sec (Fig. 7).

Proposals on the design and construction of the magnetic head by V. M. Grantham, and the development work on the feedback circuit by L. H. Good, are hereby acknowledged.

# Cine-Interval Recording Camera

By ARTHUR P. NEYHART

**A new type of electric cine-interval industrial and research recording camera, designed to produce a compact and reliable remotely controlled unit, is described. Requirements of one of the more difficult types of photographic recording, that of test aircraft instruments, are discussed. The application and results of electromagnetic clutch, as used to operate the Automax Recording Camera as both a motion picture and a still camera, are described.**

THE COMBINATION cine-interval camera used in aircraft flight-testing and other research activities can be generally described as a 35-mm camera which operates selectively as a motion picture camera and a still sequence camera.

Electrically operated and remotely controlled, this type of camera has a fixed motion picture frame rate in the 8- to 24-frame/sec range and a maximum single-frame rate of from 2 to 10 frame/sec. Continuous voltage supplied to the camera results in cine operation. Electrical pulses, usually supplied by an intervalometer or a switching device controlled by the action being recorded, produce interval operation.

The dual camera function permits the frame rate to be adjusted over a wide range to conform with the data recording frequency requirements of a particular test.

To illustrate, a test aircraft instrument recording camera may be operated as slowly as one frame per second during the climb to an altitude selected for a test. Instrument readings such as those denoting fuel consumption, engine cooling, rate of climb, developed horsepower and other pertinent data can be recorded adequately at this low frame rate. Upon reaching the required altitude, and after stabilizing for the test run, the camera is switched to a motion picture rate for the duration of the test. Because of rapid instrument reading changes which occur during most test runs, a relatively high recording rate is necessary to produce accurate data. At the conclusion of the run, the camera frame rate is reduced to record incidental descent data during the return to the field.

By not recording at higher frame rates than necessary, a considerable saving is effected in film reading, processing and in the space and weight of large film loads.

Up to the close of World War II, recording cameras of this type were largely designed and constructed by their users. This was particularly true in the aircraft industry, where about every known type of electric prime mover

Presented on October 16, 1951, at the Society's Convention at Hollywood, Calif., by Arthur P. Neyhart, Guild Laboratories, 6264 Sunset Blvd., Hollywood 28, Calif.

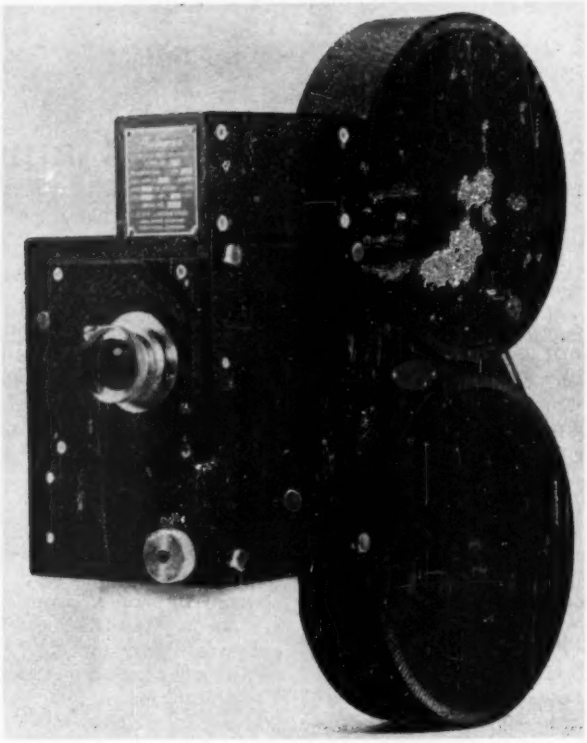

**Fig. 1. Film-loading side of camera.**

was applied to amateur and semi-professional cameras. As an example, one aircraft concern modified a DeVry Model A, 35-mm camera by adding a linear solenoid and ratchet combination to produce interval operation; cine operation was accomplished by a motor and free-wheeling drive. While this camera did a fair job, it was limited by a maximum interval frame rate of two per second, a wide variation in exposure between interval and cine operation, and frequent failures under accelerated conditions.

### Design Problems

In the design of a cine-interval camera which will produce uniform exposures during both modes of operation, certain inertia problems are encountered. A camera, which operates basically at 16 frame/sec, or 960 cycle/min, will progressively expose the film for an effective period of 15.6 msec (milliseconds) with a 90° shutter. When this shutter is of 4-in. diameter, 23 msec will elapse from the time the first corner of the frame is uncovered until the last corner is capped. To produce an interval exposure equivalent to cine exposure, therefore, a camera must operate at the rate of 960 cycle/min during the 23 msec of each cycle required for the total exposure function.

An interval frame rate of 10 frame/sec, or one frame in 100 msec, requires the

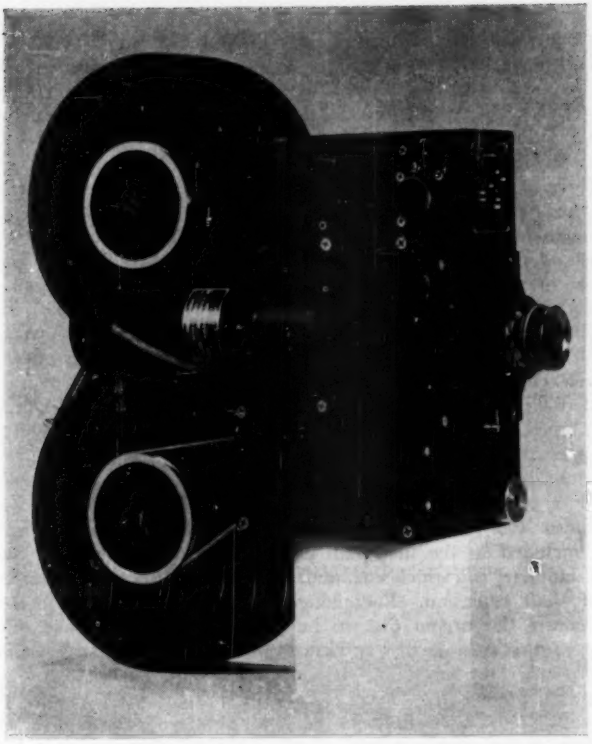

**Fig. 2. Motor-driven side of camera.**

camera to accelerate from a standstill to its cine speed in 38 msec, maintain that speed for a 23-msec exposure period, and decelerate to a stop in the remaining 38 msec of the cycle.

### Aircraft Requirements

Airborne camera design requires consideration of the special conditions under which a camera must operate. Prolonged acceleration loads up to 10 *G*'s may be applied to any axis, ambient temperatures may range from −65 F to +160 F at relative humidities to saturation. Vibration frequencies up to 100 cycle/sec at amplitudes as high as 0.02 in. are often encountered and sound levels exceeding 100 db are not uncommon. Power source voltage frequently varies from 18 to 30 v during a flight. These and many lesser conditions, independently or in combination, materially increase the performance requirements of a recording camera.

The importance of dependable operation cannot be overemphasized, whether considering cameras for aircraft applications or for recording other types of costly or dangerous research. Tests repeated because of camera failure often cost many times the price of the equipment which failed. Aircraft testing cost averages from $1500 to over $5000 per flying hour; flights often exceed 5 hr in duration. Repeating flights because of loss of data through camera failure

not only represents a money and time loss but incurs an additional risk of crew and airplane.

### Automax Recording Camera

Designed primarily for aircraft instrument recording, the 35-mm Automax camera (Figs. 1 and 2) is proving of value in other types of research recording requiring rates of 16 frame/sec and less.

A constant-speed-drive motor (Fig. 3), which may either be governer-controlled or synchronous, transmits power to the camera through an electromagnetic clutch and brake combination. The driven clutch disk, mechanically connected to the camera mechanism through a speed reducer, is positioned between a rotating driver disk integral with the motor shaft, and a stationary brake disk against which it is spring-loaded. Both the driver and driven disks are included in the flux path of a 36-ohm stationary coil which surrounds the motor shaft extension. Energizing this coil causes the driven disk to be pulled away from the brake disk and into engagement with the revolving driver disk, thus completing the mechanical coupling between the motor and camera. De-energizing the coil releases the driven disk from the driver disk to be spring returned into engagement with the brake disk which arrests its motion. During this displacement, the linear motion of the driven disk is approximately $\frac{1}{64}$ inch which is accommodated by a wide pinion on the driven disk shaft.

A cycle of operation starts midway in the film transporting period (Fig. 5). Following clutch engagement (at A) approximately 30 msec are required to bring the camera up to cine speed which is maintained for 30 msec. The exposure function occurs during this constant speed period (from C to D on the curve). In interval operation, the clutch coil is de-energized and the brake is applied (at E) following the completion of the exposure. The camera decelerates to a stop (at F) in another 30 msec, thus completing the cycle (at G) in a total of 90 msec.

To control this sequence of action, an outside electrical circuit supplies a pulse directly to the clutch coil. After the mechanism has completed one-fourth of a cycle (at B) a cam-driven switch within the camera parallels, and at the same time disconnects, this original pulse circuit. The clutch coil continues to be energized by the internal switch until after shutter closure when it is disconnected and the brake applied. The camera circuitry maintains an open switch in the external pulse circuit until the intervalometer, or other switching device, opens the original triggering circuit. When this circuit opens, the internal switch is closed to restore the original electrical configuration in readiness for the subsequent cycle. This electrical sequence prevents more than one cycle of operation occurring per pulse, regardless of duration, and also stops the camera with its shutter closed.

A push-button brake release located on the camera (Fig. 3) is for manually disengaging the motor to position the intermittent prior to film threading or the shutter for through-the-lens focusing.

An Automax will single-frame at a little more than half its cine frame rate. As an example, a 16 frame/sec camera will single-frame at 10 frame/sec.

Basic cine frame rates of 10, 16 and 24 frame/sec result from selection of standard ratios for the clutch pinion and its mating gear (Fig. 3). On cameras using d-c drive motors, these frame rates can be increased or decreased 15% by the motor governer speed adjustment.

### Intermittent Movement

A specially modified Cunningham intermittent movement, of the quick-return claw type, is used (Fig. 4). Dual positioning pins register successive frames to an accuracy of 0.0003 in., resulting in steady projection, prevention of film motion under vibration conditions and

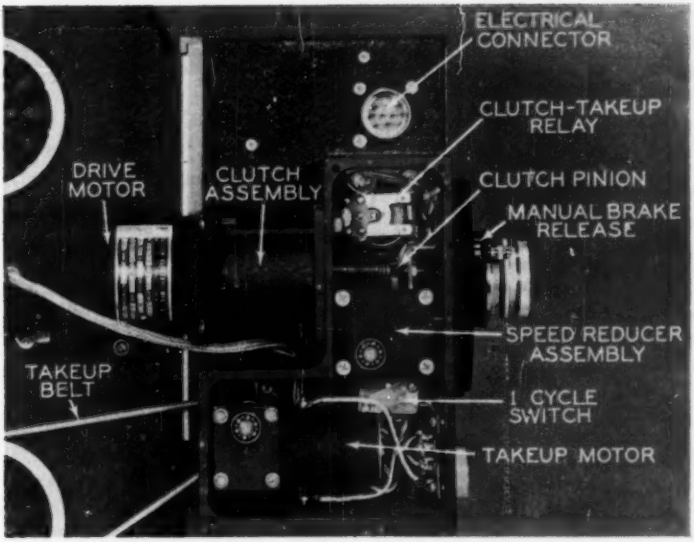


**Fig. 3. Camera drive and take-up mechanism.**

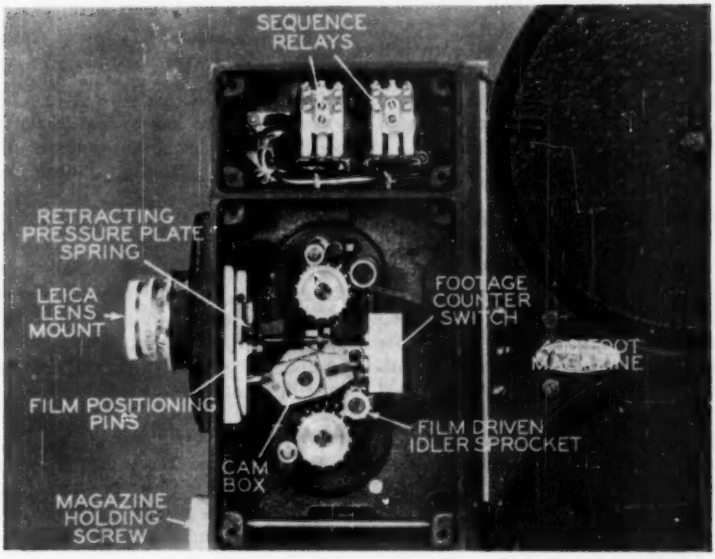


**Fig. 4. Intermittent and relay compartment with covers removed.**

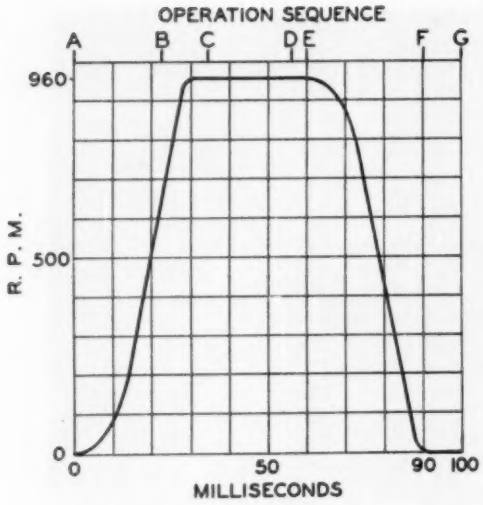


**Fig. 5. Curve of one cycle of interval operation at 10-frame/sec rate.**

A. Clutch engages.
B. Internal switch closes.
C. Shutter opens.
D. Shutter closes.
E. Brake is applied.
F. Mechanism comes to rest.
G. Start of subsequent cycle.

the accurate framing essential to the use of automatic film reading equipment. Pressure plate retraction during film transporting reduces operating torque requirements, prevents film scratching and emulsion pile-up.

A torque of 2 in-oz at 960 rpm will operate the intermittent. The camera drive applies a torque of 45 in-oz to compensate for the effect of high acceleration.

### Film Supply

400-Ft Mitchell magazines are standard. Other types and sizes are adaptable with matching pads. In applications of use under non-accelerated conditions, standard magazines are used without modification. For moderate acceleration and horizontal camera positioning, a micarta lining is substituted for the original fabric lining. Double flanged camera-type reels are advisable for use under highly accelerated conditions.

### Film Take-up

A 1/100-hp motor and spring belt drive are used for film take-up (Fig. 3). This motor is energized simultaneously with the clutch coil therefore it operates only as required. Take-up tension on the film cannot overoperate the intermittent movement because of the brake function.

### Objectives

Optional Bell & Howell or Leica lens mounts and lens-to-film dimensions permit the use of the full range of either type of lens, including 25-mm wide-angle lenses.

### Correlation Switch

A positive pulse, adjustable through the range of from 15° prior to the apex of the shutter opening to 15° after, provides for correlation with associated equipment and/or triggering of flash-tube illumination sources.

### Remote Footage Indicator

Remote indication of film supply and camera operation is provided by a film-driven idler (Fig. 4) geared to a switch which momentarily closes a circuit for each foot of film consumed. This circuit, when connected to an

electric 4-place subtractive counter, will show the amount of film remaining and provide visual indication of camera function.

**Airborne Performance Data**

*Acceleration:* 10 *G* vertical, 8 *G* parallel to the optical axis and from 3 *G* to 8 *G* parallel to the magazine spindles, depending upon the type of magazine modification.

*Vibration:* All combinations of frequencies to 100 cycle/sec and amplitudes to 0.02 in. This pertains to mechanical and electrical functions only, as relative motion between camera and subject will naturally affect the photographic function.

*Temperature:* From +150 F to −10 F. Lower temperatures require special lubrication, not suited to average conditions, or the addition of resistance heaters. When contemplating extremely high- or low-temperature applications, the effect of temperature on film should be considered.

*Radio Noise:* The camera is completely shielded but a noise filter is recommended for use in the power supply.

*Altitude:* Standard practices of high-altitude arc suppression are employed.

*Note:* The above test results were obtained with a 24-v d-c standard camera operating on 22 v d-c.

**General Description**

The two motors, speed reducers and intermittent cam shaft are ball bearing supported. Dust- and light-tight cover plates on both sides of the cast aluminum case permit rapid inspection. Each component and subassembly — motor, clutch, speed reducer, shutter, take-up drive, intermittent movement, electrical switch and relays — can be independently and readily removed or installed.

The Automax, which weighs 11 lb. without magazine, is $8\frac{3}{4}$ in. high and mounts on its $4\frac{1}{2}$-in. square base. Four positioning pins insure accurate alignment.

Of the several types of cine-interval camera modus operandi tested by this writer and his associates, the electromagnetic clutch in combination with a quality claw type intermittent appears to be the most practical from the standpoints of reliability, simplicity, low maintenance and life expectancy.

# Film Reader for Data Analysis

By WALTER M. CLARK and LEE R. RICHARDSON

**With the increased use of photographic recorders for military aircraft flight testing, there has been a need for an efficient film reading device to enable rapid evaluation of the recorded data. This paper not only introduces a projector-reader that meets this demand, but also suggests that, with certain modifications, it will be of use to the following: 1. draftsman or engineer, 2. film editor, 3. animator, and 4. rush film reviewer.**

NEVER BEFORE has so great a reliance been placed on photography to give analytical data to the aircraft engineer. In order to record reliably and satisfactorily the different components of the test vehicle during flight, expensive and dependable flight recorder cameras have been developed and are in ever increasing use. The compact on-board recorders consisting of from a few to scores of especially modified instruments, as well as the camera, are placed in some accessible area in our modern speedy military aircraft of today.

Aircraft flight photo recording has been briefly mentioned in order to show how much importance is placed on this type of recording. All these elaborate recording devices are used and yet the readers that are generally adapted to interpret this film into usable data were never designed for this purpose and are inadequate especially with the increased length of flight test films.

Presented on October 16, 1951, at the Society's Convention at Hollywood, by Walter M. Clark, Northrop Aircraft, Inc., Hawthorne, Calif., and Lee R. Richardson, Richardson Camera Co., Hollywood, Calif.

The Theory and Analysis Section of the Special Weapons Division of Northrop Aircraft, working under an Air Force contract, approachep this problem by setting about to obtain a device which would efficiently read this film in order to transduce it more quickly into usable data. Design specifications were written which directed Richardson Camera Co., the manufacturer, to incorporate into one unit a reader which would be essentially a projector and screen designed to meet the needs of the data analyst, who is required to read flight test or similar type film one frame at a time or in cine.

Since most of our recorders use 35-mm film, the reader was designed for that size, although it is a simple matter to have interchangeable mechanical panels to permit using 16-mm film. The machine as manufactured to meet these specifications is shown in Fig. 1, with all compartments and doors closed. The cabinet is made of 18 gauge steel measuring 60 in. high, 32 in. deep, and 36 in. wide and is mounted with rubber casters.

**Fig. 1. Reader — all closed up.**

**Components**

The screen has a usable area of $18\frac{7}{8}$ in. × 25 in. centered 48 in. from floor. It is a Stewart vinyl-plastic screen protected from puncture by water-white clear glass in rear of screen (this is to forego any viewing parallax). It is hinged, to allow for conventional projection for a large audience. Figure 2 shows all compartments and doors open.

A cannon connection plug was used between control panel and reader components to allow for connection of a remote control panel (if such is ever required) for use by a lecturer at the reflection screen.

If reader is used in semi-illuminated room, the screen image is easily discernible from any angle up to 70° off axis (Fig. 3). A lamp rheostat is installed to bring the screen brightness to suit the operator.

Since the machine is designed for flight test film, it has a frame aperture size to accommodate maximum usable film area — 47/64 in. by 1 in. with $\frac{3}{32}$-in. radius corners. The lens is a $3\frac{1}{2}$-in. $f/1.9$ Kollmorgen, projecting onto the rear of the screen by means of a system of three front surface mirrors with focus controlled by wheel crank and flexible shaft in the compartment below the control panel. A modified

**Fig. 2. Readar — all compartments and doors open.**

DeVry projection system is used with a 500-w lamp operating through three sets of three heat absorbing glasses. The lamphouse blower and heat absorbing glasses cool the system, such that if a single frame were to be continuously projected, it would not rise higher in temperature than 152 F.

### System of Operation

The criteria for our photo recording called for continuous monitoring in flight, but analysis of only certain sections of the film; therefore, the machine has provisions for cineviewing in variable speed up to 33 frames/sec, as well as stop motion. The operator loads the film into the projection head, turns three lock levers, closes compartment doors and is then ready for projection (Fig. 4).

### Cine

He may set controls for cine forward and push down on a variable-speed foot treadle for film viewing. As the operator approaches the section of film that requires critical analysis, he slows the reader down and removes his foot from treadle, stopping machine. He then sets the control panel knob from cine to stop motion. Upon pushing the button on the control panel or pressing the treadle, film will advance one frame

Figure 3. Screen image in partially illuminated room.

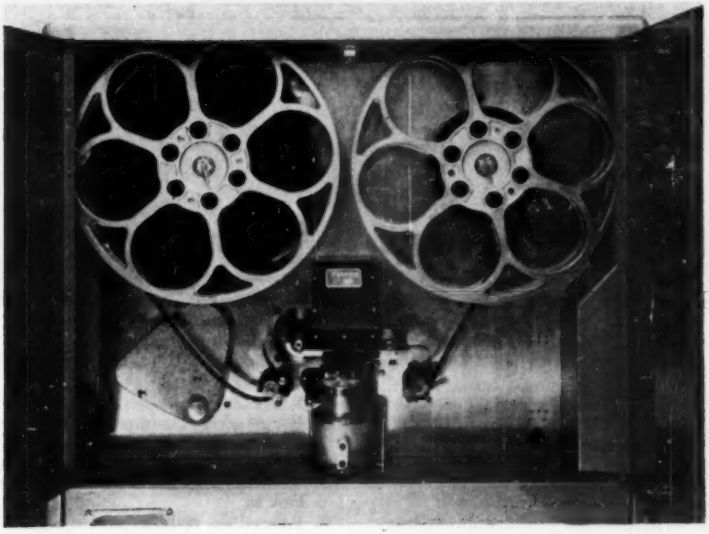

Fig. 4. Film compartment showing 2000-ft reels and projector head.

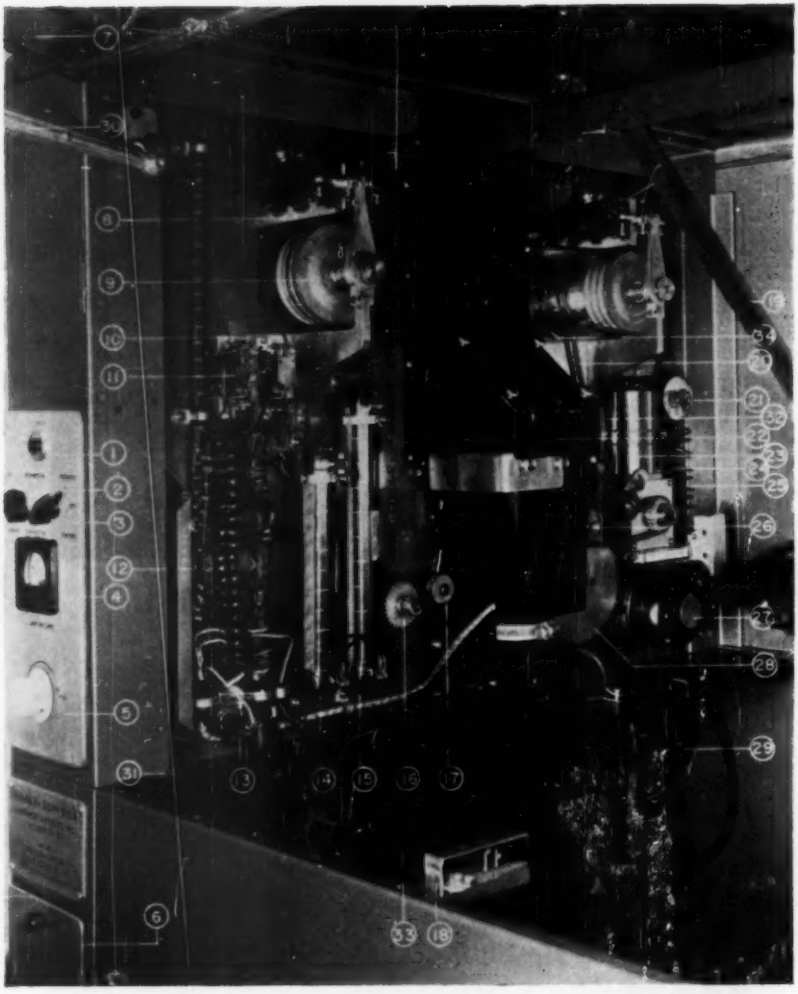

**Fig. 5. The mechanical-electrical panel, with top mirror removed.**

1. Trip button for single frame
2. Control knob for selection of:
   a. System off
   b. Stop motion
   c. Cine motion
   d. Rewind
3. Control knob for selection of:
   a. System forward (film right to left)
   b. Off (film passage stopped)
   c. System reverse (film left to right)
4. Voltmeter for projection lamp
5. Rheostat for projection lamp
6. Focus control compartment
7. Rear projection screen showing protecting glass (screen in up position)
8. Rewind solenoid for rewind tension kick in
9. Reversible spindle take-up clutch
10. Relay for solenoid trip disconnect in rewind operation

either forward or backward depending on film direction control setting.

**Stop Motion**

Film may be advanced in stop motion at any rate up to 0.1 sec between pulses and each frame will aline on the screen to within ±0.080 in. from the previous frame. When film passage is reversed, displacement of 0.750 in. results on the first frame. Since our needs do not require metric-graphic measurements, these displacements cause no concern. However, the reader was designed so that whenever time-space recordings are to be plotted, it could be modified to perform with accurate register by the installation of a register-pin film movement. Also there could be installed an analogue computer system with coordinates measuring wires operating from controls situated immediately below the screen frame.

**Rewind**

When the film is ready for rewind, the operator takes it out of the projection head, sets the rewind and film direction knobs, and presses on the foot treadle. Film rewinds in either direction 2000 ft in less than two minutes.

**Additional Uses**

In general, the reader best fits into the needs of the aircraft data analyst. However, it is felt that, since it is portable, it would fit into the needs of the motion picture industry by the addition of a sound head, and could be used as a rush film reviewer on remote location. With the addition of electrically controlled film markers, the motion picture editor would be able to mark a code on the film as he views and reviews the scenes in preparation for cutting.

By redesign of the screen from a vertical to a horizontal position, the animator would find a useful tool. In this configuration also, a drafting table could fit around the screen so that plots and tracings may be made to assist the engineer.

Figure 5 shows the mechanical electrical panel with the top mirror removed. The components are detailed in the legend.

*Acknowledgment:* The authors wish to acknowledge the sponsorship of this project by the U.S. Air Force. The requestors for the fabrication of this reader were Irving Wieselman and Bill Waddell of the Northrop Aircraft Special Weapons Division.

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11. Relay for stop motion action (time delay circuit now substituted)
12. Electrical terminal block
13. System fuse receptacle
14 & 15. Resistors for speed control
16. Drive sprocket for film feed
17. Idler
18. Projection screen latch
19. Front surface mirror holder
20. Leather belting for power drive of take-up clutches
21. Capacitor for trip solenoid
22. Lamphouse
23. Housing for stop motion trip solenoid
24. Electrical terminal block
25. Stop motion clutch
26. Intermittent drive sprocket
27. 1/8 hp Bodine motor, for cine and stop motion
28. Large sprocket wheel for feed sprocket assembly
29. Cooling fan for projection lamphouse
30. Hinge bracket for screen holdup
31. System disconnect plug; also remote control unit connection
32. Intermediate pulley wheel for power drive
33. Flexible shaft for focus control
34. Leather belting for take-up clutches

# Revised Proposed Standards of Emulsion and Sound Record Positions

MINOR REVISIONS of two American Standards, PH22.15-1946 and PH22.16-1947 ("Emulsion and Sound Record Positions in Camera for 16-Mm Sound Motion Picture Film" and "Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16-Mm Sound Motion Picture Film") were proposed by the Standards Committee in January 1951 and published for trial and comment in the May 1951 *Journal*.

Valuable comments were received and the Standards Committee voted to alter again the two proposals and to republish for another 90-day period of trial and criticism.

The changes made since the May 1951 version consist of altering paragraph 3 in both proposals to specify more definitely the relation between picture and sound and correcting "speed of projection" in paragraph 2.1 of PH22.15 to "rate of exposure."

Please forward any comments to Henry Kogel, Staff Engineer, at Society Headquarters by March 1, 1952.

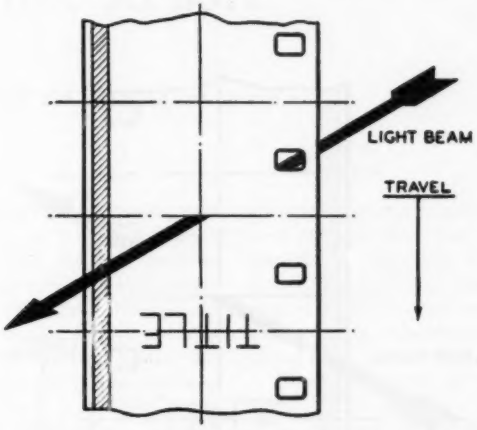
Proposed American Standard

# Emulsion and Sound Record Positions in Camera For 16-Millimeter Sound Motion Picture Film*

PH22.15

Revision of Z22.15-1946

*UDC 778.53




*Drawing shows film as seen from inside the camera looking toward the camera lens.*

## 1. Emulsion Position

**1.1** The emulsion position in the camera shall be toward the lens, except for special processes.

## 2. Rate of Frame Exposure

**2.1** The rate of exposure shall be 24 frames per second.

## 3. Distance Between Picture and Sound

**3.1** The film path distance measured in the direction of travel from the center of the picture aperture to the corresponding sound shall be 26 frames ± ½ frame.

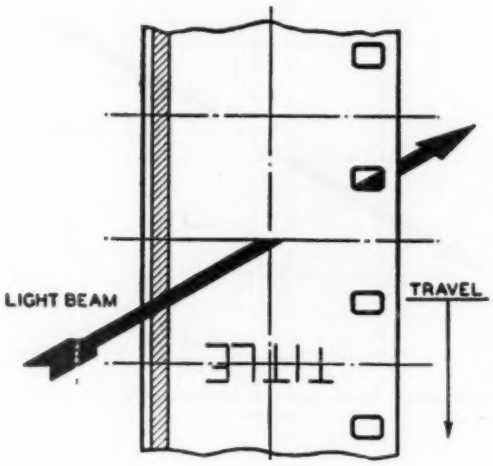
NOT APPROVED

Proposed American Standard

# Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16-Millimeter Sound Motion Picture Film

PH22.16

Revision of Z22.16-1947




*Drawing shows film as seen from the light-source in the projector.*

## 1. Emulsion Position

**1.1** The emulsion position in the projector shall be toward the lens, except for special processes.

## 2. Rate of Frame Projection

**2.1** The speed of projection shall be 24 frames per second.

## 3. Distance Between Picture and Sound

**3.1** The film path distance measured in the direction of travel from the center of the picture aperture to the corresponding sound shall be 26 frames ± ½ frame.

NOT APPROVED

# Convention Public Address Committee Report

By E. W. TEMPLIN, Committee Chairman

At the Society's 70th Semiannual Convention a new public address-recording system was used for the first time. This equipment had been engineered and assembled over the past six months by the Eastern Public Address and Recording Committee under the Chairmanship of Harry Braun and was assembled and tested at Society headquarters by Fred Whitney.

The equipment consisted of:

*1. Pickup equipment:* Two Altec condenser microphones for chairman and speaker; four 633 microphones for floor positions.

*2. Mixer.* Providing separate adjustment of the preamplifier output of each microphone.

*3. Gray Audograph.* Operated on output of mixer for recording extemporaneous comments or papers not available in written form at the time of presentation.

*4. Power Amplifier and Loudspeakers.* For speech reinforcement in the auditorium.

The function of the Public Address Committee was to set up the equipment at the Convention and to operate it at each session excepting those held at remote locations. Vic Allen, the Society's Editor, was on hand at each session to advise the operator about any special requirements, such as recording all of the remarks of one or two speakers who did not have final copies of their papers. A relatively large number of Committee members were appointed so that it would not be necessary for one person to be responsible for more than one session.

Those appointed to the Committee were:

J. A. Beranek, Columbia Broadcasting System
J. P. Corcoran, Twentieth Century-Fox
O. L. Dupy, Metro-Goldwyn-Mayer
J. K. Hilliard, Altec Lansing
J. A. Larsen, Academy Films
F. W. Moran, Universal
J. L. Pettus, RCA
G. E. Sawyer, Sam Goldwyn
W. L. Thayer, Paramount

The sessions were held in the Blossom Room of the Hollywood Roosevelt Hotel except where noted otherwise, below. The persons assigned to the operation of the equipment were as follows:

Monday afternoon: Wm. Schneller, CBS
Monday evening: Frank Moran, Universal
Tuesday morning: Roy Roglin, Westrex
Tuesday afternoon: Phil Thomas, Westrex
Tuesday evening. Session held at CBS Studio A. Public address facilities were provided locally through ar-

rangements made with Messrs. Pangborn and Beranek of CBS.

Wednesday morning: John Stork, Altec

Wednesday afternoon: Allan Wolff, Westrex (equipment moved to Aviation Room)

Thursday morning: Jim Corcoran, Twentieth Century-Fox (equipment moved back to Blossom Room)

Thursday afternoon: Jim Pettus, RCA

Thursday evening: Session held at Republic Studios. Equipment used was the new Stevens Radio Link supplied by Stevens Manufacturing Co. and RYK, Inc. This was operated into public address equipment furnished locally through arrangements with Dan Bloomberg of Republic Studios.

Friday afternoon: J. Valentino, MGM

Friday evening: Session held at Paramount Studio. Public address facilities were furnished locally through arrangements with Dr. C. R. Daily and William Thayer of Paramount.

Each of the above kept a log of notes about identity of discussers, location of discussions on disks, etc. This log proved very valuable when the staff came to transcribe the discussion.

The equipment functioned very satisfactorily throughout the entire period. No difficulties whatever were encountered in the initial setting up of the equipment. The following comments may be useful in connection with subsequent applications of this equipment:

1. The power supply fuse in the power amplifier failed during one of the sessions but was put back in operation again within less than a minute. A 1½-amp slo-blo fuse had been installed. Mr. Hilliard of Altec agreed that a 2-amp or 3-amp slo-blo fuse would give safer protection against inadvertent failure of the fuse without sacrificing protection against short circuits in the amplifier. It is recommended that this change in fuse capacity be made.

2. It was found desirable to locate one of the floor microphones at the mixer operator's position. This was occasionally useful to advise a person speaking from the floor to move to a microphone or to repeat his name and company affiliations, etc., and also to ask a speaker to stop speaking for the interval required to change a record. The rear floor microphone was used for this purpose. In some auditoriums where all four microphones are required on the floor, a fifth microphone should be available for the operator's position.

3. Some operators preferred mixer controls without detents. The present mixer pots could easily be modified if desired.

4. Audio-frequency oscillation occurred in one of the Altec condenser microphones two or three times during the Convention. Mr. Hilliard explained that this was a defect in the vacuum tube used in the preamplifier and that it occurs in a very small percentage of the tubes. When this persists, it is necessary to discard the offending tube.

5. Considerable care was required in the particular rooms used at this Convention to prevent acoustic feedback through the public address system. It was necessary to place the loudspeakers well forward of the nondirectional microphones used at the speaker's and chairman's positions. The quality from these microphones was excellent and many complimentary remarks concerning them were received during the Convention. However, in rooms where acoustic feedback is particularly troublesome, directional microphones at these two positions would reduce the possibility of trouble.

The West Coast Chairman of the Public Address Committee has greatly appreciated the excellent cooperation and assistance received throughout the Convention period from those listed above. Thanks also are due Boyce Nemec and R. T. Van Niman, who by suggestion and assistance made many contributions to the proper functioning of the Public Address Committee.

# New Society Emblem— Report of the Special Committee

By L. D. GRIGNON, Committee Chairman

[The following report has been recast in the past tense for *Journal* reading, compared with the form in which it was presented on October 13, 1951, to the Society's Board of Governors.

[Design of a new official Society emblem was proposed at the time of changing the Society's name in January 1950 and the task of producing suggested layouts, then assigned to an Emblem Committee, has now been completed. During the intervening two years, two committees worked diligently on designs that would be suitable for stationery and the *Journal* cover, and symbolize the expanded scope, implied by addition of Television to the Society's name. Since one of three proposals submitted by the second Emblem Committee received approval at the Board of Governors Meeting in Hollywood on October 13, 1951, the story of its evolution is being told here.]

The final Emblem Committee decided to operate as a screening group to reduce the number of potential designs already at hand to five, those to be submitted to the Officers and Managers of the Society's Sections whose votes would further reduce the favored designs to three.

The Committee first voted on a group of ten designs made up of the two most favored designs left over from the work of the earlier Committee and all recent designs not previously considered. Designs had been submitted or proposed by a considerable number of individuals or organizations:

Eastman Kodak Co.,
C. R. Keith, member,
Minnotte-Williams Studios,
Dr. A. N. Goldsmith, member,
Eric Wybrow, member,
Walter Bach, member,
L. D. Grignon, member,
Columbia Broadcasting System,
Engineering Department,
Reid H. Ray Film Industries,
Naval Photographic Center,
Paramount Pictures Inc.,
Art Department,
Twentieth Century-Fox Films Corp.,
Art Department,
Melvin Stewart, art student.

All told, the two Committees examined 37 designs based on 23 distinct ideas. Obviously, there was a substantial coverage of ideas; although with more time other, and perhaps better, designs might be obtainable.

The preferential votes of the members were tallied by three methods and in each case the same five designs were favored. One member considered none of the designs as suitable and another

voted for only the one design which he considered as desirable. The other member made several suggestions for modification of the various designs. It was convenient to execute an obvious modification of one of the favored proposals prior to transmission to the Section Officers, so this was done.

The five designs screened were sent to the Chairmen of the three local sections with the request that all of the officers vote preferentially for three designs and list separately the preference of as many other Society members as might be conveniently obtained. By the same methods of tally as before the three most favored designs, numbered 3, 8 and 9, were chosen. A total of 34 members were also polled and the same three designs were favored.

[The breakdown by different methods of tallying as well as brief suggestions and comments by voters are omitted here.]

There was one particularly significant fact notable in the total vote: except for those few who cast their ballot for less than three designs, every person polled voted in some way for No. 8, which was not true for Nos. 3 and 9.

Of the persons polled, three thought none of the designs of high quality and one suggested we continue the temporary emblem now in use.

In view of the relative standing of the three designs in which No. 9 was always third choice, it was recommended that no further consideration be given that design. Numbers 3 and 8, being very close in the balloting, were both recommended to the Editorial Vice-President and to the Board of Governors as candidates for final selection, if they were deemed suitable. It was suggested that comments as to printability, usefulness and adaptability as a lapel pin be obtained from the *Journal* Editor. The monochrome exhibits which accompanied the report to the Board were rendered in three sizes to enable judging their suitability in small sizes. Also included were exhibits of possible color schemes.

[After discussion following Chairman Grignon's Report, the Board by secret ballot voted the adoption of No. 8 (the one submitted by Melvin Stewart, art student).]

This is it—

# Awards

The fields of interest of the Society are served in one way, among others, by an attempt to recognize formally important contributions by individuals. Several awards are conferred annually upon those whose work has been considered significant in their particular fields of interest. Those who were selected during 1951 were presented awards during the Fall Convention of the Society in Hollywood. Their names and awards are listed here.

As has been done in past years there were published earlier this year, in April, the recommendations, citations, and former recipients of the Progress Medal Award, the Samuel L. Warner Memorial Award, and the Journal Award. Recommendations and description of the David Sarnoff Gold Medal Award first presented in 1951 were given in the June *Journal*.

### New Fellows of the Society

President Mole formally inducted the following as new Fellows of the Society:
*Don M. Alexander*, Alexander Film Co., Colorado Springs, Colo.
*Clarence S. Ashcraft*, C. S. Ashcraft Manufacturing Co., Long Island City, N.Y.
*Louis A. Bonn*, J. E. Brulatour, Inc., New York
*Howard A. Chinn*, Columbia Broadcasting System, New York
*Alan A. Cook*, Wollensak Optical Co., Rochester, N.Y.
*Ellis W. D'Arcy*, De Vry Corp., Chicago
*William C. De Vry*, De Vry Corp., Chicago
*O. B. Hanson*, National Broadcasting Co., New York
*William F. Kelley*, Motion Picture Research Council, Hollywood
*Frank La Grande*, Paramount Pictures, New York
*Cornelius G. Mayer*, RCA International Div., New York
*Otto H. Schade*, RCA Tube Div., Harrison, N.J.
*Hubert J. Schlafly*, Twentieth Century-Fox, New York
*Vaughn C. Shaner*, Eastman Kodak Co., Hollywood
*Ethan M. Stifle*, Eastman Kodak Co., New York
*Lloyd Thompson*, The Calvin Co., Kansas City, Mo.

### Journal Awards

The Journal Award went to *A. B. Jennings*, *W. A. Stanton* and *J. P. Weiss* of the Technical Div., Photo Products Dept., E. I. du Pont de Nemours & Co., Inc., Parlin, N.J., for their "Synthetic Color-Forming Binders for Photographic Emulsions," which was published in November 1950.

*C. E. Ives* and *C. J. Kunz*, of the Eastman Kodak Co., Rochester, N.Y., received honorable mention for their "Simplification of Motion Picture Processing Methods," which appeared in the *Journal* for July 1950.

Honorable mention was conferred on *Pierre Mertz*, of the Bell Telephone Laboratories, New York, for "Perception of Television Random Noise," which appeared in the January 1950 *Journal*.

### Special Commendation Award

Each member of the Color Sensitometry Subcommittee of the Color Committee received a scroll in honor of his work on the "Principles of Color Sensitometry" report. This Special Commendation Award was made at the Wednesday night banquet of the

**Earl I. Sponable, Past President of the SMPTE, and technical director of 20th Century-Fox, receives two awards—the first man to be so honored by the Society. Awards were made for outstanding contributions to technical advancement of the motion picture art. Participating in the presentation are (from left) Col. Nathan Levinson, Sound Director of Warner Bros., Jack Warner, Production Executive, who presented the annual Samuel L. Warner Memorial Award, Mr. Sponable and Peter Mole, SMPTE President, who conferred the 1951 Progress Medal. Presentations took place at the Wednesday banquet at the Convention.**

Convention to *C. F. J. Overhage*, Editor, and his confreres: *H. E. Bragg, L. E. Clark, J. G. Frayne, A. M. Gundelfinger, C. R. Keith, G. C. Misener, H. W. Moyse, S. P. Solow, M. H. Sweet, J. P. Weiss, J. A. Widmer, F. C. Williams* and *H. H. Duerr*. Dr. Duerr as Chairman of the Color Committee authorized and guided preparation of the noteworthy report.

**Progress Medal and Samuel L. Warner Memorial Award**

*Earl I. Sponable*, Technical and Research Director of Twentieth Century-Fox and Past-President of the Society, received the Progress Medal and the Samuel L. Warner Memorial Award during the Wednesday night banquet at the Convention, thus becoming the first man to receive the two awards simultaneously. The Warner Award was presented to Mr. Sponable by Col. Nathan Levinson, Sound Director of Warner Bros.

President Peter Mole presented the Progress Medal which the Society conferred "in recognition of outstanding contributions to the technical advancement of the motion picture art, particularly with respect to sound on film, color and large screen television." This formal citation was read by D. B. Joy, Chairman of the Committee which made the selection. All of Mr. Sponable's professional efforts have been channeled in a single broad constructive direction and it was the unanimous view of the Committee that the results of his efforts were far more than adequate qualification because they "resulted in a significant advance in the development of motion picture technology."

**Otto H. Shade of the RCA Tube Dept., Harrison, N. J., receives from President Peter Mole the David Sarnoff Gold Medal Award for outstanding achievement in television engineering.**

Mr. Sponable first gained prominence shortly after World War I for his development of most of the electrical and mechanical units required for a complete system of sound-on-film recording and reproduction, constituting the basis for the sound motion pictures of today. In 1927, he helped develop the first sound newsreel and, under his supervision, expanded it into a worldwide news coverage medium. He has also been a pioneering leader in the development of equipment and techniques for large-screen theater television.

It was for Mr. Sponable's years of research and development work in the recording of sound-on-film that the Samuel L. Warner Memorial Award was most appropriately presented.

**David Sarnoff Gold Medal Award**

The David Sarnoff Gold Medal Award, for outstanding technical achievements in the field of television and motion pictures, was first presented this year to Otto H. Schade of the RCA Tube Dept., Harrison, N.J., at the luncheon opening the Convention. Selection of the recipient was made by a committee under chairmanship of Pierre Mertz. Presentation of the award, established in 1951 by the Radio Corporation of America and named in honor of its Board Chairman, was made by SMPTE President Peter Mole.

In appraising Mr. Schade's qualifications the Committee cited him for his recent work in evaluating the gradation, graininess and sharpness in motion picture and television images, and his proposed generalized aperture theory by which the performance of camera lenses, films, television tubes and their circuits may be combined and specified for the first time in objective mathematical terms.

The award was presented to Mr. Schade "for his outstanding accomplishments in the fields of television and motion picture science and engineering, in outlining the potentialities of television and film systems as to fidelity of photography and reproduction of images."

## HONORARY MEMBERS

Lee de Forest
Edward W. Kellogg
A. S. Howell
V. K. Zworykin

***The distinction of Honorary Membership in the Society is awarded to living pioneers whose basic contributions when examined through the perspective of time represent a substantial forward step in the recorded history of the arts and sciences with which the Society is most concerned.***

## SMPTE HONOR ROLL

Louis Aimé Augustin Le Prince
William Friese-Greene
Thomas Alva Edison
George Eastman
Frederic Eugene Ives
Jean Acme Le Roy
C. Francis Jenkins
Eugene Augustin Lauste
William Kennedy Laurie Dickson
Edwin Stanton Porter
Herman A. DeVry
Robert W. Paul
Frank H. Richardson
Leon Gaumont
Theodore W. Case
Edward B. Craft
Samuel L. Warner
Louis Lumiere
Thomas Armat

***Elevation to the Honor Roll of the Society is granted to each distinguished pioneer who during his lifetime was awarded Honorary Membership or whose work was recognized subsequently as fully meriting that award.***

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# Engineering Activities

As mentioned in the November issue, six Engineering Committees scheduled meetings at the 70th Convention in Hollywood. Three (High-Speed Photography, Sound and Laboratory Practice) were described in the previous issue and the key aspects of the last three will be outlined below.

**Color** *1. Lighting for Color Films:* At present, three different types of tungsten bulbs are in use, having color temperatures of 3200 K, 3350 K and 3400 K. The advantages of standardizing on one were enumerated and the related engineering factors discussed. Dr. Duerr, Chairman, questioned whether this project was properly one for Color Committee consideration. In a subsequent discussion with Mr. Kelley of the Research Council, Mr. Bowditch was informed that the subject is receiving active experimental consideration in many studios with insufficient data presently at hand to justify the specification of a single preferred color temperature.

*2. Laboratory Processing of Color Film:* It was noted that the processing of the color film of the three manufacturers is very similar in many respects, but that the differences are sufficient to provide serious problems for the laboratories where the present-day economics of the situation preclude specializing in just one of the three processes. Recommendations were made that the film manufacturers cooperate to eliminate the differences. This might more appropriately be considered by the Laboratory Practice Committee, but could very well be a joint project of both groups.

**Screen Brightness** *1. Theater Survey of Screen Brightness:* Ways and means for utilizing the recently completed survey report (published in the September 1951 *Journal*) for improving the viewing conditions in theaters were discussed. Specific recommendations are to be formulated by Wallace Lozier, Chairman, in a brief article for release to the motion picture trade papers.

*2. Subcommittee on Meters and Methods of Measurements:* Fred Kolb, Chairman of this Subcommittee, submitted an extensive and detailed report for consideration. Upon receiving the Committee's approval, the report will be submitted for *Journal* publication.

*3. Recommended Practices for Screen Illumination:* The Committee agreed that the theater survey could very well supply the basis for formulating Recommended Practices for illumination of motion picture screens and for the distribution of the illumination. A subcommittee is to be formed to prepare a draft for Committee consideration.

*4. Review of Screen Brightness Standard, PH22.39:* Based on a recently completed ballot, the Committee decided to revise the present standard by limiting its application to indoor theaters. This recommendation is to be forwarded shortly to the Standards Committee.

**Film Dimensions** The main discussion revolved about the problems introduced by use of low shrink film. A new standard was proposed based on PH22.34, present cine-negative standard, but with altered values for the pitch dimensions B and L. The appendix to the proposed standard contains a definition of "low shrink film." A letter ballot of the full Committee is the next step.—*Henry Kogel*, Staff Engineer.

## Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

**American Cinematographer**

vol. 32, Aug. 1951

Three-Dimension Movies, in Color (p. 306) *R. V. Bernier*

The New Arriflex 16mm Camera (p. 309) *R. Scott*

Shooting News Films for Television (p. 312) *D. L. Conway*

vol. 32, Sept. 1951

Color Correction—What it Means (p. 354) *A. E. Murray*

Duke University Makes Own Teaching Films (p. 356) *E. Porter*

Rangertone Sprocketless Magnetic Tape Recorder (p. 358) *R. H. Ranger*

New All-Purpose Film Leader Benefits TV Film Producers (p. 363) *L. Allen*

**Audio Engineering**

vol. 35, Oct. 1951

Technique of Record Processing (p. 21) *L. S. Goodfriend*

**British Kinematography**

vol. 19, Aug. 1951

Television Image Kinematography (p. 36) *W. D. Kemp*

The Screen at the Festival of Britain Telekinema (p. 51) *J. L. Stableford*

vol. 19, Sept. 1951

The Rational Application of Special Processes to Film Production, Pt. I, Introduction to Special Processes (p. 69) *T. W. Howard*; Pt. II, The Choice of Process (p. 73) *A. Junge*

Notes on the Accuracy of Measurements of the Luminance and Illumination of Kinema Screens (p. 77) *H. H. W. Losty and F. S. Hawkins*

The Manufacture of Photographic Chemicals (p. 83)

**Canadian Journal of Technology**

vol. 29, Sept. 1951

A Continuous Motion Camera for Multiple Exposure of 35mm Film (p. 401) *E. L. R. Webb*

**Electronics**

vol. 24, Sept. 1951

Crispening Circuit for Color TV (p. 85)

Dot Arresting Improves TV Picture Quality (p. 96) *K. Schlesinger*

vol. 24, Nov. 1951

Television Streaking Test Set (p. 96) *R. K. Seigle*

**Ieternational Projectionist**

vol. 26, Aug. 1951

Stereoscopic Motion Pictures (p. 12) *J. A. Norling*

vol. 26, Oct. 1951

Is Lenticulated Color-Film Practical? (p. 5) *R. A. Mitchell*

Projection in Britain's "Telekinema" (p. 11) *A. Bowen, J. Moir and H. Turner*

**Kino-Technik**

no. 4, Apr. 1951

Polarisiertes Licht in der Kinotechnik (p. 66) *W. Selle*

Der neue Askania Projektor AP XII (p. 68) *K. Schencke*

no. 5, May 1951

Kino-Technik im Internationalen Blickfeld (p. 87)

Film im Fernsehen (p. 93) *H. Jungfer*

Ein Neues System von Tonwiedergabe analgen (p. 96) *H. Schmidt*

Beschichtung und Regenerierung von Kinofilmen (p. 98) *H. W. Tromnau*

Der Philips FP7-Projektor (p. 100)

no. 6, June 1951

Herstellung von farbigen Bild-Kombinationsaufnahmen nach dem Prinzip der Wandermaske (p. 110) *E. Mutter*

Ein neues System von Tonwiedergabeanlagen (p. 114) *H. Schmidt*

"Aquaflex" die 35-mm-Unterwasser Kamera (p. 116) *W. Beyer*

Störungen bie der Vorführung von Tonfilmen *H. Tümmel*

no. 7, July 1951

Herstellung von farbigen Bild-Kombinationsaufnahmen nach dem Prinzip der Wandermaske (p. 134) *E. Mutter*

no. 8, Aug. 1951

Der neue Super-Parvo mit Spiegelreflexblende (p. 155) *W. Beyer*

Störungen bei der Vorführung von Tonfilmen (p. 161) *D. Braune and H. Tümmel*

**Motion Picture Herald**

vol. 185, Oct. 13, 1951 (Better Theatres)

Theatre Television in Terms of Motion Picture Projection (p. 12) *G. Gagliardi*

Ballantyne Announces New Model Soundhead and a Screen Tower (p. 38)

The Operation and Maintenance of Theatre Television Equipment, Pt. II, The Picture Tube (p. 41) *A. Nadell*

vol. 185, Nov. 1951 (Better Theatres)

How Today's Lamps Can Make Movies Better Than Ever (p. 21) *G. Gagliardi*

**Proceedings of the I.R.E.**

vol. 39, Oct. 1951

Alternative Approaches to Color Television (p. 1124) *D. G. Fink*

Color Television of Colorimetry (p. 1135) *W. T. Wintringham*

Subjective Sharpness of Additive Color Pictures (p. 1173) *M. W. Baldwin, Jr.*

Methods Suitable for Television Color Kinescopes (p. 1177) *E. W. Herold*

A Three-Gun Shadow-Mask Color Kinescope (p. 1186) *H. B. Law*

A One-Gun Shadow-Mask Color Kinescope (p. 1194) *R. R. Law*

A 45-Degree Reflection-Type Color Kinescope (p. 1201) *P. K. Weimer and N. Rynn*

A Grid-Controlled Color Kinescope (p. 1212) *S. V. Forgue*

Development and Operation of a Line-Screen Color Kinescope (p. 1218) *D. S. Bond, F. H. Nicoll and D. G. Moore*

Phosphor-Screen Application in Color Kinescopes (p. 1230) *N. S. Freedman and K. M. McLaughlin*

Three-Beam Guns for Color Kinescopes (p. 1236) *H. C. Moodey and D. D. Van-Ormer*

Mechanical Design of Aperture-Mask Tricolor Kinescopes (p. 1241) *B. E. Barnes* and *R. D. Faulkner*

Effects of Screen Tolerances on Operating Characteristics of Aperture-Mask Tricolor Kinescopes (p. 1245) *D. D. Van Ormer and D. C. Ballard*

Deflection and Convergence in Color Kinescopes (p. 1249) *A. W. Friend*

Recent Improvements in Band-Shared Simultaneous Color-Television Systems (p. 1264) *B. D. Loughlin*

Analysis of Dot-Sequential Color Television (p. 1280) *N. Marchand, H. R. Holloway* and *M. Leifer*

Color Television—U.S.A. Standard (p. 1288) *P. C. Goldmark, J. W. Christensen and J. J. Reeves* (also in *Jour. SMPTE, 57:* 336–381, Oct. 1951)

A New Technique for Improving the Sharpness of Television Pictures (p. 1314) *P. C. Goldmark and J. M. Hollywood* (also in *Jour. SMPTE, 57:* 382–396, Oct. '51)

Spectrum Utilization in Color Television (p. 1323) *R. B. Dome*

Observer Reaction to Low-Frequency Interference in Television Pictures (p. 1332) *A. D. Fowler*

**Radio & Television News**

vol. 46, Nov. 1951

Practical Sound Engineering (p. 72) *H. M. Tremaine*

**Tele-Vision Engineering**

vol. 2, Sept. 1951

Oscillating Color Sequence in Color TV (p. 18) *R. G. Peters*

# Book Reviews

### TV Films: How to Produce Them

By The Chalmers Sisters. Published (1951); distributed by American Photography, 421 Fifth Ave. South, Minneapolis 15, Minn. 102 pp. + 4 pp. index. Illustrated. 4¼ × 6 in. Price $1.00.

This is not a formal book.

It is a pocket handbook telling the novice "how to do it." As such, its value cannot be disputed, particularly to those who wish to start producing motion pictures in a small way for television, church or similar markets.

Our novice might well purchase this book before he purchases equipment, not that he should necessarily buy the brands recommended but so that he should know what to demand in return for his capital.

Perhaps nowhere else will one find a complete guide in such small size; the chapters range from how to write your own script to how to market your product, from the psychology of directing to a check list for shooting, and how to edit and synchronize sound with picture. The technical error in their explanation of *why* sound is printed 26 frames ahead of sight does not result in misinformation as to what to do in practice.

If you have had professional experience in Hollywood or elsewhere you will not need this book. But if you are new in the game, you will find it stimulating and helpful.—*Harry R. Lubcke*, Consultant, 2443 Creston Way, Hollywood 28, Calif.

### The Producer

By Richard Brooks. Published (1951) by Simon and Schuster, Rockefeller Center, New York 20. 337 pp. 5½ × 8¼ in. Price $3.50.

This is a novel about today in Hollywood and a producer who in his time and place is another Babbitt. The author has been writing and directing motion pictures since World War II and as a novelist he is already known for *The Brick Foxhole* (1945) and *The Boiling Point* (1948).

There is no warning printed at the front of this book that "any resemblance to persons living or dead..."—so, except for what may be strictly autobiographical, the book is intended to depict a composite of the producer in Hollywood. As such, it is successful and valid: it neither paints too much in black nor tries to make a lily-white picture. The choices in gray scale are good and there is transmitted a picture that is lively and colorful without gilded lilies.

If a few scenes and conversations appear flat, the book's overall effect is that of some depth and perspective, a well made picture, well focused and projected. It will light and help bring into focus those nontechnical aspects of motion picture production which are huffed and puffed greatly in the trade and general press. And it will provide a couple of evenings of interesting entertainment.—V.A.

### Radio, Television, and Society

By Charles A. Siepmann. Published (1950) by Oxford University Press, 114 Fifth Ave., New York 11. i-vii + 410 pp. 5½ × 8¼ in. Price $4.75.

This is an absorbing and educative primer (with footnotes), oriented for the United States reader who never knew or does not remember the chaos and static in the nursery of the baby radio industry. And the book offers much for those who are wondering how the newer broadcasting brat, television, will turn out. There is perforce much said about the Federal Communications Commission and its predecessors but even so there is no guarantee that the reader will come to understand every FCC decision, including those on color television.

The author throws much clear light on both the attacks on, and the campaigns on behalf of, advertising in our system of broadcasting. There are thorough comparisons with the British system, and with the Canadian system which stands part way between those of the United States and Great Britain.

The author is well qualified. He was 12 years with the British Broadcasting Corp. for which he was Director of Program Planning and a member of the Corporation's Control Board. A Rocke-

feller Foundation fellowship brought him to the United States in 1937 to study and report on broadcasting over educational stations. In 1939–42 he was a university lecturer and adviser to President Conant of Harvard. During World War II he was with the Office of War Information. In 1945 he served as consultant to the FCC and was one of the authors of its "Blue Book." Since 1946 he has been Professor of Education at New York University and Director of its Film Library. He also completed before this book a commissioned survey of broadcasting in Canada.

This is not a technical book but it will help make less confounded a variety of governmental and business decisions about technical matters.—V.A.

## Gas Discharge Lamps

By G. Funke and P. J. Orange. Published (1951) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Publishing Co., 250 Fifth Ave., New York 1. i-xvi + 242 pp. + 28 pp. appendix. 200 illustrations. 6 × 9 in. Price $4.50. English edition.

This is a survey, made by scientists on the staff of the Philips company, of existing types of discharge lamps marketed by that company and a compilation of published work by members of its engineering staff.

The book opens with a good discussion of the fundamental principles of the electrical discharge lamp, some of the underlying reasons for the current-voltage relation found in them, the necessity for special operating equipment, and the general effect of such equipment on the characteristics of the lamp.

Specific discussions cover, for instance, the sodium lamp, for which are given its general physical make-up, its electrical characteristics and the radiation output. Some of the claims, however, made for this lamp as a unit for street lighting have not been substantiated by those interested in street lighting in this country. Two chapters on the characteristics and uses of high-pressure mercury-vapor lamps include a discussion of the effect of this type of light on vision. A compact array of information on the operation and light-giving properties of the fluorescent lamp is fitted into fifty pages, followed by a chapter on beacons and luminous advertisements, and another on stroboscopic and flash tubes.

The appendixes include a list of definitions, and some reference to the works of other engineers in addition to the extended list of papers by Philips engineers already mentioned. The 200 figures and photographic reproductions are well planned. Such books as this, however, would be much easier to read if the generally adopted nomenclature were followed and if the various lamps were referred to either by name or by a description instead of by such designations as Type ML, HO, HP, etc.—*W. E. Forsythe* (Editor, *Physical Tables* of the Smithsonian Institution), 15006 Terrace Road, Cleveland 12, Ohio.

**Back Issues of the Journal Available**

The issues of Jan. 1930, all of 1931 through 1933; Nov. 1934, and all of 1935 through 1951 are available for any reasonable offer for the lot from: Stanley A. Lukes, 6427 Sheridan Rd., Chicago 26, Ill.

**American Standards form the technical foundation** for motion pictures around the world. All current standards were listed by subject and by number in the *Journal* Index 1946–1950. Reprint copies of this list, which includes all previous *Journal* references to each standard, are available from Society Headquarters without charge.

Complete sets of all sixty current standards in a heavy three-post binder with the index are $13.50, plus 3% sales tax for purchases within New York City, and are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 East 45th St., New York 17, N.Y.

# New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY,

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

**Adams, Robert F.,** University of Buffalo. **Mail:** 1271 Wyoming Ave., Niagara Falls, N.Y. (S)

**Aller, Lawrence L.,** Projection Engineer, Universal-International Pictures Co. **Mail:** 15152 Hesby St., Sherman Oaks, Calif. (A)

**Allred, J. D.,** Motion Picture Photographer, University of Nebraska. **Mail:** 1025 W. 45 St., Lincoln, Nebr. (A)

**Andres, Edward A., Sr.,** Photographic Engineer, USAF, Wright-Patterson Air Force Base. **Mail:** 1300 Carlisle Ave., Dayton 10, Ohio. (M)

**Anthony, Berkeley F.,** Training Film Coordinator, Lockheed Aircraft Corp. **Mail:** 7918 Bellingham Ave., North Hollywood, Calif. (A)

**Austin, Charles,** Representative, Mitchell Camera Corp. **Mail:** 1093 Jerome Ave., New York 52, N.Y. (M)

**Beckett, Robert W.,** University of Southern California. **Mail:** 2315 S. Flower, Apt. 417, Los Angeles 7, Calif. (S)

**Bohr, John W. F.,** Film Director and Editor, Dept. of Education, Film Services. **Mail:** P.O. Box 1592, Pretoria, Union of South Africa. (A)

**Brault, Andre R.,** President, Optomechanisms, Inc. **Mail:** 58 Whaleneck Rd., Merrick, L.I., N.Y. (M)

**Brown, Fordyce M.,** Physicist, Kenyon Instrument Co., 1345 New York Ave., Huntington Station, N.Y. (M)

**Byrne, John P.,** Motion Picture Sensitometrist, Signal Corps Photographic Center. **Mail:** 41–15—48 St., Long Island City 4, N.Y. (M)

**Cart, William L.,** Projectionist, United Paramount Tenarken Division. **Mail:** 1212 W. Fourth St., Owensboro, Ky. (A)

**Clarke, William R.,** University of Southern California. **Mail:** 427 S. Alexandria Ave., Los Angeles 5, Calif. (S)

**Courtney, Larry,** University of Southern California. **Mail:** 1209½ W. 30 St., Los Angeles 7, Calif. (S)

**Engel, H. Bob,** General Sales Manager, Golde Manufacturing Co. **Mail:** 3318 Lake Shore Dr., Chicago, Ill. (A)

**Folks, Charles C.,** Motion Picture Technician, Dept. of State, Foreign Service. **Mail:** APO 205, c/o Postmaster, New York, N.Y. (A)

**Gilbert, Ellis A.,** Motion Picture Camera Manufacturing, Berndt-Bach, Inc. **Mail:** 1830 N. Cherokee Ave., Hollywood 28, Calif. (A)

**Glenn, James A.,** Manager, Special Effects Dept., National Broadcasting Co. **Mail:** 34–40—79 St., Jackson Heights, N.Y. (M)

**Greenberg, Wilfred,** SRT Television Studios. **Mail:** 14 Grafton St., Brooklyn 12, N.Y. (S)

**Gums, John R.,** Service Manager, Swank Motion Pictures, Inc. **Mail:** 4169A Shenandoah, St. Louis 10, Mo. (M)

**Hauver, Clifford C.,** Photographic Technologist, U.S. Naval Research Laboratory. **Mail:** 4003 Oliver St., Hyattsville, Md. (A)

**Hirsch, Sidney,** School of Radio Technique. **Mail:** Box 4, Lumberville, Bucks County, Pa. (S)

**Hogan, Alsede W.,** Electronic Engineer, American Radio & Television Corp. **Mail:** Box 1082, Brownsville, Tex. (A)

**Joseph, George E.,** School of Radio Technique. **Mail:** 16 Christopher St., New York 14, N.Y. (S)

**Kral, Karel Bedrich,** Director, Manager, Griffin Film Enterprises, Ltd. **Mail:** Griffin Lodge, Betsham, Nr. Gravesend, Kent, England. (M)

**Kruttschnitt, Pell,** University of Southern California. **Mail:** 1745 N. Gramercy Pl., Hollywood 28, Calif. (S)

**Lakebrink, Robert T.,** Teacher-Laboratory Chief, American Television Institute of Technology. **Mail:** 4529 N. Malden St., Chicago 40, Ill. (A)

**Leahy, J. V.,** Contact Engineer, Film Recording, RCA Victor Div., 411 Fifth Ave., New York 18, N.Y. (A)

**Levonian, Edward,** University of Southern California. **Mail:** 1533 Fourth Ave., Los Angeles 19, Calif. (S)

**Lindsay, Raymond A.,** Camera Research, Jerry Fairbanks, Inc. **Mail:** 2031 Argyle Ave., Hollywood 28, Calif. (M)

**LoPresti, Paul J.,** Sound Recordist, Reeves Sound Studios, Inc. **Mail:** 2763 Reservoir Ave., Bronx, N.Y. (A)

**Lownsbery, 1st Lt. Robert,** Director of Television, Signal Corps Mobile TV Detachment. **Mail:** Officers Mail Rm., Bldg. T-521, Fort Monmouth, N.J. (A)

**Lytle, John,** Producer, 16-Mm Sound Motion Pictures, Slides, Slide Films. **Mail:** 410 W. First St., Dayton 2, Ohio. **(A)**

**Maurer, Edwin A.,** National Schools. **Mail:** 13809 S. E. Division, Portland 66, Ore. **(S)**

**Metzger, Charles H.,** Photographer. **Mail:** 7038 East Ave., Cincinnati 36, Ohio. **(M)**

**Milira, Ken,** University of Southern California. **Mail:** 1122 W. 37 Dr., Los Angeles 7, Calif. **(S)**

**Murtough, William L.,** Broadcast Engineer, Columbia Broadcasting System. **Mail:** 255–11—75 Ave., Glen Oaks, N.Y. **(A)**

**Ogura, Juzo,** Managing Director, D. Nagase & Co., Ltd., 7 Itachibori Minamidori 1 Chome, Osaka, Japan. **(A)**

**Otto, Roy S.,** Projection Engineer, Universal-International Studios. **Mail:** Box 255, Universal City, Calif. **(A)**

**Parlan, Stanley,** Television Film Director, National Broadcasting Co. **Mail:** 24 E. 82 St., New York 28, N.Y. **(A)**

**Polister, Richard C.,** University of Southern California. **Mail:** 1138 Browning Blvd., Los Angeles, Calif. **(S)**

**Pourciau, Louis L.,** Engineer, General Precision Laboratory. **Mail:** 13 Manville La., Pleasantville, N.Y. **(M)**

**Roberts, Fred G., Jr.,** President and Salesman, Training Aids, Inc. **Mail:** 4429 Sherman Oaks Cir., Sherman Oaks, Calif. **(A)**

**Sager, Clifton G.,** 16-Mm Film Producer. **Mail:** Route #1, Grafton, Wis. **(M)**

**Sandbo, Robert,** Herbert Kerkow, Inc. **Mail:** 40 W. 96 St., New York 25, N.Y. **(A)**

**Schreiber, E. H.,** Staff Engineer, Pacific Telephone & Telegraph Co., Rm. 858. 740 S. Olive St., Los Angeles 55, Calif. **(A)**

**Serdy, Henry W.,** Motion Picture Photographer, Allis-Chalmers Co. **Mail:** 1500 S. 57 St., West Allis 14, Wis. **(A)**

**Shamberg, Kurt D.,** New Inst. for Film and Television. **Mail:** 80-50 Forest Parkway, Woodhaven, L.I., N.Y. **(S)**

**Strang, John,** SRT Television Studios. **Mail:** 353 W. 57 St., New York 19, N.Y. **(S)**

**Tubbs, G. Christian,** SRT Television Studios. **Mail:** 251 W. 74 St., New York 23, N.Y. **(S)**

**Unk, Jaap M.,** Professor, Electrical Engineering, Delft University. **Mail:** S Gravelandsche Weg So., Hilversum, The Netherlands. **(A)**

**Waver, Frank H.,** University of Southern California. **Mail:** 1220 Fifth Ave., Los Angeles, Calif. **(S)**

**Wilkinson, Frank H.,** Sound Technician, Universal Studio. **Mail:** 4956 Laurel Canyon Blvd., North Hollywood, Calif. **(A)**

**Winkler, Lew,** Television Maintenance Engineer, National Broadcasting Co. **Mail:** 11444 Oxnard St., North Hollywood, Calif. **(A)**

**Wolber, John R., Jr.,** University of Southern California. **Mail:** 6117 Glen Alder, Hollywood 28, Calif. **(S)**

**Yeager, J. Harry,** Motion Picture Cameraman and Projectionist, St. Louis Amusement Co. **Mail:** 1026 Sylvan Pl., Kirkwood 22, Mo. **(A)**

**Zurek, Val C., Sr.,** Supervisor, Motion Picture Laboratory, General Film Laboratory. **Mail:** 4355 E. Outer Dr., Detroit 34, Mich. **(A)**

## CHANGES IN GRADE

**Abramson, Albert,** Teacher, Los Angeles City School. **Mail:** 3441 W. Second St., Los Angeles 4, Calif. **(S)** to **(A)**

**Frost, Floyd A.,** Cinematographer, U.S. Government. **Mail:** Box 220, China Lake, Calif. **(S)** to **(A)**

**George, Samuel R.,** TV Technician, RCA Victor Div. **Mail:** 1026 N. Crescent Heights Blvd., Hollywood 46, Calif. **(S)** to **(A)**

**Gillette, Frank N.,** Development Engineer, General Precision Laboratory. **Mail:** Manville La., Pleasantville, N.Y. **(A)** to **(M)**

**Harwood, Erwin G.,** Secretary and Treasurer, National Cine Equipment, Inc. **Mail:** 514 West End Ave., New York 24, N.Y. **(A)** to **(M)**

**Jalas, Clarence A.,** Partner, Essannay Electric Manufacturing Co. **Mail:** 188 W. Randolph St., Chicago, Ill. **(A)** to **(M)**

**Long, Charles R.,** District Engineer, Motion Picture and Television Lighting, Westinghouse Lamp Div., 600 St. Paul Ave., Los Angeles 17, Calif. **(A)** to **(M)**

**Mann, Gordon P.,** Manager, Ansco Technical Service Dept. **Mail:** E. Maine Rd., R.D. #1, Johnson City, N.Y. **(A)** to **(M)**

**Noble, Joseph V.,** Consultant, Motion Picture Film Counselors. **Mail:** 107 Tuscan Rd., Maplewood, N.J. **(A)** to **(M)**

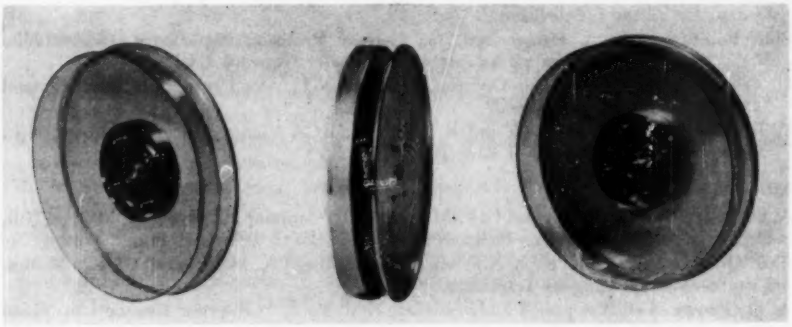
**Opochinsky, David,** Vice-President, Titra Film Laboratories, Inc. **Mail:** 320 W. 76 St., New York 23, N.Y. **(A)** to **(M)**

**Pettus, J. L.,** Mechanical Design Engineer, RCA Victor Div. **Mail:** 1560 N. Vine St., Hollywood, Calif. **(A)** to **(M)**

**Sherwood, Larry,** Vice-President, The Calvin Co., 1105 Truman Rd., Kansas City, Mo. **(A)** to **(M)**

# New Products

Further information about these items can be obtained from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of news items does not constitute an endorsement.



**A combination reel and film can** is made in one unit called the Reel-Can by the manufacturers, Thalhammer Specialties, 10219 Eldora Ave., Sunland, Calif.

Made of metal, it is designed to save metal, money and time. There is a special film-threader with spring clamp to attach film to reel. The lid is constructed so that when it is fixed by spring lock and pins to the base with rim upwards the rim serves as the side of the reel. When the lid is inverted, with rim down, and fastened by the same spring lock and pins, it becomes the lid of the storage can.

A 200-ft, 8-mm Reel-Can costs $1.50 postpaid. Other sizes in both 8-mm and 16-mm are planned.

**The 1952 edition of the RCA Pocket Reference Book** has been announced by the RCA Tube Dept., Harrison, N.J. It is also available from RCA distributors.

This year's is a revised edition, expanded to include information on products introduced during the past year, so that it now contains complete product listings and data on the characteristics, interchangeability and socket requirements of more than 450 RCA receiving tubes, including kinescopes, with similar data on 75 dry batteries. Other sections of the book include: a selection guide for power, cathode-ray, photo and special tubes; a section on radio and television test equipment and trouble shooting; and a description of available technical literature on the various RCA products.

# Papers Presented at the Hollywood Convention, October 15–19

**MONDAY AFTERNOON**

Otto H. Schade, RCA Tube Dept., Harrison, N.J., "Requirements for a Theater Television System Giving Detail Contrast Equivalent to 35-Mm Motion Pictures."

F. N. Gillette, General Precision Laboratory, Pleasantville, N.Y., "A Direct-Projection System for Theater Television."

Blair Foulds and E. A. Hungerford, Jr., General Precision Laboratory, Pleasantville, N.Y., "A Television Camera Adaptable to Theater Network Use."

L. T. Sachtleben, RCA Victor Division, Camden, N.J., "An Ultra-High-Speed Optical System for Theater Television."

P. J. Herbst, J. M. Brumbaugh and R. O. Drew, RCA Victor Division, Camden, N.J., "Factors Affecting Quality of Kine Recordings."

**MONDAY EVENING**

A. G. Jensen, R. E. Graham and C. F. Mattke, Bell Telephone Laboratories, Murray Hill, N.J., "A Continuous Motion Picture Projector for Use in Television Film Scanning."

A. S. Quiroga and C. G. Pierce, American Broadcasting Co., Hollywood, Calif., "Motion Picture-Type Lighting in Television."

A. D. Fowler, Bell Telephone Laboratories, New York, "Observer Reaction to Video Crosstalk in Television Pictures."

G. C. Higgins and L. A. Jones, Eastman Kodak Co., Rochester, N.Y., "A Method of Making Objective Measurements Which Correlate With Subjective Picture Sharpness."

**TUESDAY MORNING**

B. B. Jackson and F. M. Ashbrook, U.S. Naval Ordnance Test Station, Inyokern, Calif., "Time Coordination of Photographic Instrumentation on Missile Range."

M. G. Holland and D. E. Dunn, North American Aviation, Los Angeles, Calif., "High-Speed Photography and High-Speed Aircraft."

E. C. Barkofsky, U.S. Naval Ordnance Test Station, Inyokern, Calif., "Multiple-Image Silhouette Photography for Aeroballistics Research."

J. H. Waddell, Wollensak Optical Co., Rochester, N.Y., "High-Speed Photography of Moving Objects."

D. H. Peterson, Peterson & Pease, Glendale, Calif., "The Rotoscope as a High-Speed Camera Accessory."

John Kudar, Consultant, Hollywood, Calif., "Optical Problems in High-Speed Camera Design."

**TUESDAY AFTERNOON**

R. O. Painter, General Motors, Proving Ground Section, Milford, Mich., "Techniques for Effective High-Speed Photography and Analysis."

Walter M. Clark, Northrop Aircraft, Inc., Hawthorne, Calif., and Lee R. Richardson, Richardson Camera Co., Hollywood, Calif., "Film Reader for Data Analysis."

A. P. Neyhart, Guild Laboratories, Manhattan Beach, Calif., "Cine-Interval Recording Camera."

G. J. Badgley and W. R. Fraser, U.S. Naval Photographic Center, Washington, D.C., "New Automatic Film-Threading Motion Picture Camera."

H. V. Hilker, U.S. Naval Ordnance Test Station, Inyokern, Calif., "High-Speed Camera Calibration."

R. K. Bucher, U.S. Naval Ordnance Test Station, Inyokern, Calif., "New Power Supply for the Fastax Camera."

**TUESDAY EVENING**

Harry Lubcke, Consulting Engineer, Hollywood, Calif., "Color Television Reproducers."

R. S. O'Brien, Columbia Broadcasting System, New York, "Conversion of Monochrome Studio Equipment for Color Standards."

D. E. Foster, Hazeltine Research of California, "Some Fundamental Considerations in Color Television."

W. E. Evans, Stanford Research Inst., Stanford, Calif., "Color Television — Order or Chaos."

**WEDNESDAY MORNING**

Lt. Lowell O. Orr, Navy Motion Picture Exchange, Brooklyn, N.Y., and Philip M. Cowett, Bureau of Ships, Navy Dept., Washington, D.C., "Desirable Characteristics of 16-Mm Entertainment Film for Naval Use."

C. R. Carpenter, Pennsylvania State College, "A Scientific Approach to Informational-Instructional Film Production and Utilization."

M. A. Kerr, Dept. of Physics, Wheaton College, Wheaton, Ill., "High Fidelity Film Reproduction of What?"

J. K. Hilliard, Altec Lansing Corp., Beverly Hills, Calif., "Application Notes on the Use of 35-Mm and 16-Mm Film in Television and Armed Forces."

Norwood Simmons, *Moderator*, "Emulsion Position of 16-Mm Positives," a panel discussion with 11 participants from the floor and on the panel.

**WEDNESDAY AFTERNOON**

A. C. Robertson, Eastman Kodak Co., Rochester, N.Y., "Dimensions of 16-Mm Film in Exchanges."

R. L. Sutton, K. B. Curtis and Lloyd Thompson, The Calvin Co., Kansas City, Mo., "Prints from 16-Mm Originals."

J. G. Streiffert, Eastman Kodak Co., Rochester, N.Y., "The Radial-Tooth Variable-Pitch Sprocket."

A. L. Holcomb, Westrex Corp., Hollywood, Calif., "Film-Spool Drive With Torque Motors."

J. W. Kaylor and A. V. Tesek, Cinecolor Corp., Burbank, Calif., "The Cinecolor Multi-Layer Color Developing Machine."

C. R. Dupree, Signal Corps Photographic Center, Long Island City, N.Y., "The Application of Magnetic Clutches for Conversion of Sprocket-Drive Developing Machines to Friction Drive."

**THURSDAY MORNING**

Kurt Singer and H. C. Ward, RCA Victor Division, Hollywood, Calif., "A Technical Solution of Magnetic Recording Cost Reduction."

Kurt Singer and J. L. Pettus, RCA Victor Division, Hollywood, Calif., "A Building Block Approach to Magnetic Recording Equipment Design."

Marvin Camras, Armour Research Foundation, Chicago, Ill., "A New Magnetic Recording Head."

Edward Schmidt, Reeves Soundcraft Corp., New York, "Manufacture of Striped and Full-Width Professional Magnetic Films."

L. L. Ryder, Paramount Pictures Corp., Hollywood, Calif., "Use of Magnetic Stripe Track."

L. L. Ryder and B. H. Denney, Paramount Pictures Corp., Hollywood, Calif., "Standard Placement of 35-Mm Magnetic Track."

**THURSDAY AFTERNOON**

C. E. Hittle, RCA Victor Division, Hollywood, Calif., "Twin-Drum Film-Drive Filter System for Magnetic Recorder-Reproducer."

C. C. Davis, J. G. Frayne and E. W. Templin, Westrex Corp., Hollywood, Calif., "A Multichannel Magnetic Film Recording and Reproducing Unit."

G. A. Del Valle and F. L. Putzrath, RCA Victor Division, Camden, N.J., "Optical-Magnetic 16-Mm Sound Projector."

H. W. Pangborn, Columbia Broadcasting System, Hollywood, Calif., "The Use of ¼-In. Magnetic Tape for Kinescope Sound Rebroadcast Purposes."

H. E. Haynes, RCA Victor Division, Camden, N.J., "A New Principle for Electronic Volume Compression."

**THURSDAY EVENING**

H. H. Duerr (Committee Chairman), Ansco, Binghamton, N.Y., "Color Committee Report."

H. H. Duerr, Ansco, Binghamton, N.Y., "The Ansco Color Negative-Positive Process for Motion Pictures."

R. H. Ray, Reid H. Ray Film Industries, Inc., St. Paul, Minn., "Use of Ansco Type 843 35-Mm Color Film in Commercial Production."

C. R. Anderson, N. H. Groet, C. A. Horton and D. M. Zwick, Eastman Kodak Co., Rochester, N.Y., "An Intermediate Positive-Internegative System for Color Motion Picture Photography."

A. M. Gundelfinger, Cinecolor Corp., Burbank, Calif., "Supercinecolor Process."

Bela Gaspar, Gasparcolor, Inc., Hollywood, Calif., "Gaspar Color Process and Demonstration."

S. P. Solow, Consolidated Film Industries, Hollywood, Calif., "The Trucolor Process."

**FRIDAY AFTERNOON**

L. D. Grignon, Twentieth Century-Fox Films, Beverly Hills, Calif., "Recent Improvements in Silencing Engine-Driven Generators."

G. L. Dimmick and M. E. Widdop, RCA Victor Division, Camden, N.J., "A Heat Transmitting Mirror."

W. W. Lozier, National Carbon Co., Fostoria, Ohio, and F. T. Bowditch, National Carbon Co., Cleveland, Ohio, "Carbon Arcs for Motion Picture Studio Lighting."

L. L. Ryder and C. A. Hisserich, Paramount Pictures Corp., Hollywood, Calif., "New Remote-Control Light-Weight Incandescent Lighting Equipment."

R. T. Van Niman, "Report on Lead Sulfide Photo-Electric Cell."

W. W. Lozier (Committee Chairman), National Carbon Company, Fostoria, Ohio, "Screen Brightness Committee Report."

**FRIDAY EVENING**

L. D. Grignon, Twentieth Century-Fox Films, Beverly Hills, Calif., "Preliminary Report of Special Committee on Picture Flicker."

I. M. Terwilliger, Inspacian Enterprises, Hollywood, Calif., "Depth Dimension Accomplishments by Inspacian Systems."

Norman McLaren, The National Film Board of Canada, Ottawa, Ont., Canada, "Stereographic Animation."

Raymond Spottiswoode, Harrow-on-the-Hill, Middlesex, England, "Production and Projection of Three-Dimensional Film."

John G. Stott, Du-Art Film Laboratories, New York, "The Tri-Art Color Laboratory."

M. L. Gunzburg, Natural Vision Corp., Hollywood, Calif., "Natural Vision Three-Dimension."

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40 West 40th Street, New York 18, N. Y. Tel. LOngacre 5-0172

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**1951**

G. W. Colburn, 164 N. Wacker Dr., Chicago 6, Ill.
C. R. Daily, 113 N. Laurel Ave., Los Angeles 36, Calif.
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F. E. Carlson, General Electric Co., Nela Park, Cleveland 1, Ohio
William B. Lodge, 485 Madison Ave., New York 22, N. Y.
Thomas T. Moulton, 4475 Woodley, Encino, Calif.
Oscar F. Neu, 330 W. 42 St., New York 18, N. Y.
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